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**SITE-SPECIFIC TECHNICAL REPORT**

for

**SHORT-TERM PILOT TEST FOR THE BIOSLURPING FIELD INITIATIVE  
AT TRAVIS AFB, FAIRFIELD, CALIFORNIA**

by

**J.A. Kittel, L.A. Smith, M.C. Place, D.C. Foor, and E. Drescher**

for

**MR. PATRICK HAAS  
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE  
BROOKS AFB, TEXAS 78235**

**May 1, 1995**

**BATTELLE  
505 King Avenue  
Columbus, Ohio 43201-2693**

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## EXECUTIVE SUMMARY

This report summarizes the field activities conducted at Travis AFB (TAFB), CA, Area G or Jet Fuel Storage Area 1 (JFSA-1) for a short-term field pilot test of vacuum-enhanced free-product recovery (bioslurping) in comparison to traditional free product techniques. The field testing at TAFB is part of the Bioslurping Field Initiative which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE). The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficacy of bioslurping technology for (1) the recovery of light, nonaqueous-phase liquid (LNAPL) from groundwater and the capillary fringe; and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

The main objective of the Bioslurping Field Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and to identify site parameters that are reliable predictors of bioslurping performance. To allow measurement of LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at TAFB is one of at least 35 similar field tests to be conducted at various locations throughout the United States and its possessions.

The intent of field testing is to collect data to support a determination of the predictability of LNAPL recovery, and to evaluate the applicability, cost, and performance of the bioslurping technology for removal of free product and remediation of the contaminated area. The testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method in this study included an initial evaluation of site variables followed by LNAPL recovery testing. The specific test objectives, methods, and results for the TAFB test program are discussed in the following sections. The three technologies used at TAFB to recover the free LNAPL floating on the water table were skimmer pumping, vacuum-enhanced pumping (bioslurping) at the oil/water interface, bioslurping at 18 in. below the oil/water interface, and drawdown pumping at both 18 in. and 30 in. below the oil/water interface.

Site characterization activities were conducted to evaluate site variables that could affect the efficiency of LNAPL recovery and to determine the bioventing potential of the site. Testing included soil sampling, slug testing, in situ respiration testing, and baildown testing.

Following the site characterization activities, the actual pilot tests for the skimmer pumping, bioslurping, and drawdown pumping were conducted. The bioslurper system was installed in an



existing extraction well, well #5303. The pilot test sequence was as follows: 1 day in the skimmer mode (no vacuum); 1 day in bioslurping (vacuum-mediated) mode at the oil/water interface; 4 days in the bioslurper mode with the drop tube at 18 in. below the interface; 1 day in the drawdown mode (groundwater depression mode) with the drop tube at 18 in. below the interface; and 2 days in the drawdown mode with the drop tube at 30 in. below the oil/water interface. Free product was not collected during the skimmer-mode test and the bioslurper test with the drop tube at the oil/water interface because heavy rains before and during the pilot test changed the level of the water table. The water table needed to be lowered before any free product could be recovered. Therefore, the drop tube was placed 18 in. below the water table for the bioslurper test. Measurements of the extracted soil gas composition, free product thickness, and groundwater level were made throughout the testing. The volumes of LNAPL recovered and groundwater extracted were quantified over time.

At the TAFB site, only the bioslurping and drawdown recovery configurations were able to recover LNAPL from well #5303. The rates of recovery for the first day of bioslurping (18 in. below oil/water interface) and drawdown (18 in. and 30 in. below oil/water interface) modes of operation were 6.78 gal/day, 3.25 gal/day, and 3.38 gal/day, respectively. The rate of recovery for the bioslurper decreased over time to 3.85 gal/day, but was still greater than the recovery rate for either of the drawdown modes of operation. The skimmer pump test was unable to recover any LNAPL from well #5303. Clearly, LNAPL recovery was significantly enhanced by the application of the bioslurper/vacuum-enhanced recovery technology.

Furthermore, the vacuum-enhanced pilot test also demonstrated the ability of the technology to increase oxygen concentrations in the vadose zone to over the undisturbed oxygen-limited conditions.

Implementation of bioslurping at the TAFB test site will likely facilitate enhanced recovery of LNAPL from the water table and should also initiate simultaneous in situ biodegradation of hydrocarbons in the vadose zone via low-flow vapor extraction (bioventing). The expanded and extended testing planned for TAFB will examine the aspects of long-term viability for the bioslurping technology at this site.



## **DRAFT**

### **SITE-SPECIFIC TECHNICAL REPORT**

**for**

### **SHORT-TERM PILOT TEST FOR THE BIOSLURPING FIELD INITIATIVE AT TRAVIS AFB, FAIRFIELD, CALIFORNIA**

**May 1, 1995**

## **1.0 INTRODUCTION**

This report describes the activities performed and data collected during a field test of vacuum-enhanced pumping (bioslurping) at Travis Air Force Base (TAFB), California. The field testing at TAFB is part of the Bioslurping Field Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE). The AFCEE Bioslurper Initiative is a multi-site program designed to evaluate the efficiency of bioslurping technology for (1) recovery of light, nonaqueous-phase liquid (LNAPL) from groundwater and the capillary fringe and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

### **1.1 Objectives**

The main objective of the Bioslurping Field Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate the efficiency of bioslurping and to identify site parameters that are reliable predictors of bioslurping performance. To allow measurement of LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at TAFB is one of at least 35 similar field tests to be conducted at various locations throughout the United States and its possessions. Aspects of the testing program that apply to all sites are described in the *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). Test provisions specific to activities at TAFB are described in a site-specific test plan.

The intent of field testing is to collect data to support determination of the predictability of recovery of LNAPL, and to evaluate the applicability, cost, and performance of the bioslurping



technology for removal of free product and remediation of the contaminated area. The onsite testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with more conventional LNAPL recovery technologies. The test method included an initial evaluation of site variables followed by LNAPL recovery testing. The specific test objectives, methods, and results for the TAFB test program are discussed in the following sections. The three technologies used at Travis AFB to recover the free LNAPL floating on the water table were skimmer pumping, vacuum-enhanced pumping (bioslurping) at the oil/water interface and 18 in. below the oil/water interface, and drawdown pumping at 18 in. and 30 in. below the oil/water interface.

## **1.2 Testing Approach**

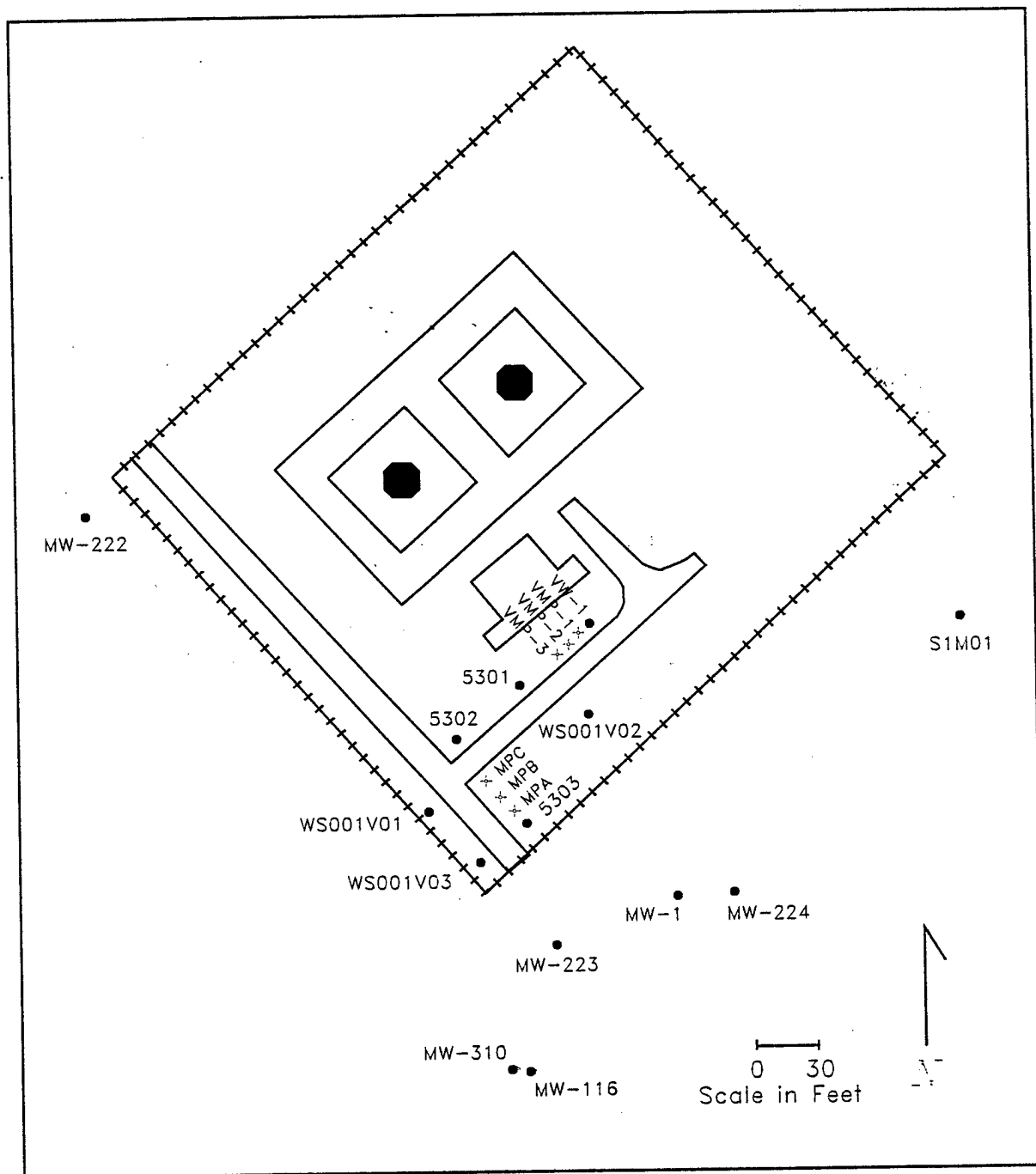
Initial site characterization activities were conducted to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. These activities included soil sampling to determine physical/chemical site characteristics, slug tests to evaluate the hydrogeologic conditions near the test well, and in situ respiration testing to evaluate site microbial activity.

Following the site characterization activities, the actual pilot tests for the skimmer pumping, bioslurping (vacuum-enhanced pumping), and drawdown pumping were conducted. The bioslurper system was installed so that an existing groundwater extraction well, well #5303, could be used for the testing. The LNAPL recovery testing was conducted in the following sequence: 1 day in the skimmer mode at the oil/water contact (no vacuum); 1 day in the bioslurper mode (vacuum-mediated mode) at the oil/water interface; 4 days in the bioslurper mode 18 in. below the oil/water interface; and 3 days in the drawdown mode (groundwater depression mode), including 1 day with the drop tube 18 in. below the oil/water interface and 2 days with the drop tube 30 in. below the interface. In general, the tests were run immediately one after another in sequence. Measurements of the extracted soil gas composition, free product thickness, and groundwater level were made throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

## **2.0 SITE DESCRIPTION**

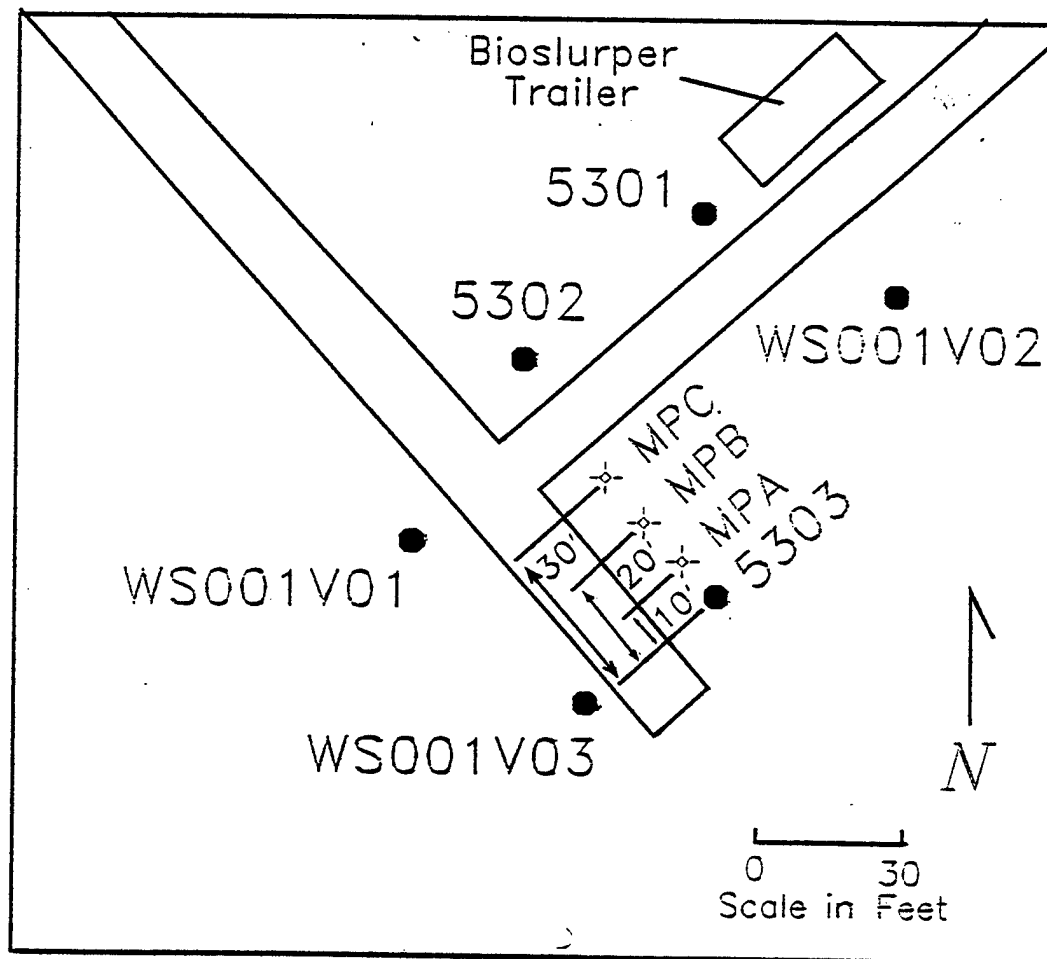
Figure 1 displays the location of the main features within the area used for the pilot testing. Well #5303 is located in the northeast corner of the fuel storage area. A diagram of the general arrangement of the extraction well and soil gas monitoring points is shown in Figure 2. Site





**Figure 1. Location and Arrangement of Bioslurper Test Site on Travis Air Force Base**





**Figure 2. General Arrangement of Bioslurper Monitoring Points and Equipment at the Test Site**



personnel indicate that a JP-4 fuel spill near the center of JFSA-1 is the most likely source of contamination in the area. Previous characterization of the site reported that the thickness of free product within the test area ranged from 0.2 to 2.0 ft during one sampling event. In addition, soil-gas total petroleum hydrocarbons (TPH) and benzene concentrations in the pilot test area ranged from 30 to 940 ppm and 0.7 to 11 ppm, respectively.

Groundwater extracted at TAFB cannot be directly discharged to the base sanitary sewer system or storm sewer system. It first must be analyzed for contamination from benzene, toluene, ethylbenzene and xylenes (BTEX) and for TPH contamination before it can be discarded. To conduct the pilot tests, an arrangement was made with the base point of contact (PoC) to hold the extracted groundwater until it could be disposed of properly to the TAFB industrial waste treatment facility. A 21,000-gal holding tank located within JFSA-1 was used to hold groundwater extracted during the short-term pilot testing. Base personnel made all the arrangements for disposal of the groundwater. Vapor discharge was limited to 165 lb of TPH/day. Due to the relatively low concentration of TPH compounds in the off-gas and the relatively low air-flow rate, the discharge levels remained below the regulated limit.

### **3.0 BIOSLURPER SHORT-TERM PILOT TEST METHODS**

This section describes the test equipment and methods used for the short-term pilot test at TAFB and documents the initial conditions at the test site.

#### **3.1 Initial LNAPL/Groundwater Measurements and Baildown Testing**

Well #5303 was selected for installation of the test equipment because it had the thickest layer of free product and historically had the greatest LNAPL recovery. Potential initial LNAPL thickness measurements and depth to groundwater were completed using an oil/water interface probe (ORS Model# 1068013). A typical baildown test was not completed on the wells because a free-product recovery system was still operating when the Battelle staff members arrived at the site.



### 3.2 Monitoring Point and Thermocouple Installation

On January 11 and 12, 1995, three monitoring points were installed in the area of extraction well #5303. The monitoring points (MPs) were labeled MPA, MPB, and MPC. A cross section of the monitoring points showing the site's lithology and well installation detail is displayed in Figure 3.

A soil gas sample collection probe, connected to ¼-in. tubing, was used to establish each sampling level in a monitoring point. The soil gas probe was 1 inch in diameter and had a 6-in. screened interval to sample soil gas. The probe was positioned at the appropriate depth, and then the annular space corresponding to the screened length of the soil gas sample collection probe was filled with silica sand. The interval between the screened lengths was filled with bentonite clay chips, as was the space from the top of the shallowest monitoring point up to ground surface. The bentonite clay was hydrated with water after placement to expand the chips and develop a seal. The soil gas probes in the monitoring points were installed at the following depths as shown in Figure 3:

- MPA was installed 10 ft south of well #5303 and drilled to a depth of 9.5 ft with a borehole diameter of approximately 4 inches. Sampling points were placed at three depths in the borehole with the bottom of the sampling screens at 3.0, 5.5, and 8.0 ft.
- MPB was installed 20 ft south of well #5303 and drilled to a depth of 9.0 ft with a borehole diameter of approximately 4 inches. Sampling points were placed at three depths in the borehole with the bottom of the sampling screens at 3.0, 5.5, and 8.0 ft.
- MPC was installed 30 ft south of well #5303 and drilled to a depth of 10.0 ft with a borehole diameter of approximately 4 inches. Sampling points were placed at three depths in the borehole with the bottom of the sampling screens at 2.0, 5.5, and 8.0 ft.

Type K thermocouples were installed in MPA at depths of 3.0 and 8.0 feet.

### 3.3 Soil Sampling and Analyses

Four soil samples were collected during the installation of the monitoring points. Approximately 400 g of soil was collected at the capillary fringe (7.0 to 7.5 ft) from monitoring points MPA and MPC. The samples were collected using a hand-driven sampler with a 6-in. brass sleeve. The soil samples were labeled as follows: JFSA-1-MPA-1 (7-7.5 ft), JFSA-1-MPC-1 (7-7.5



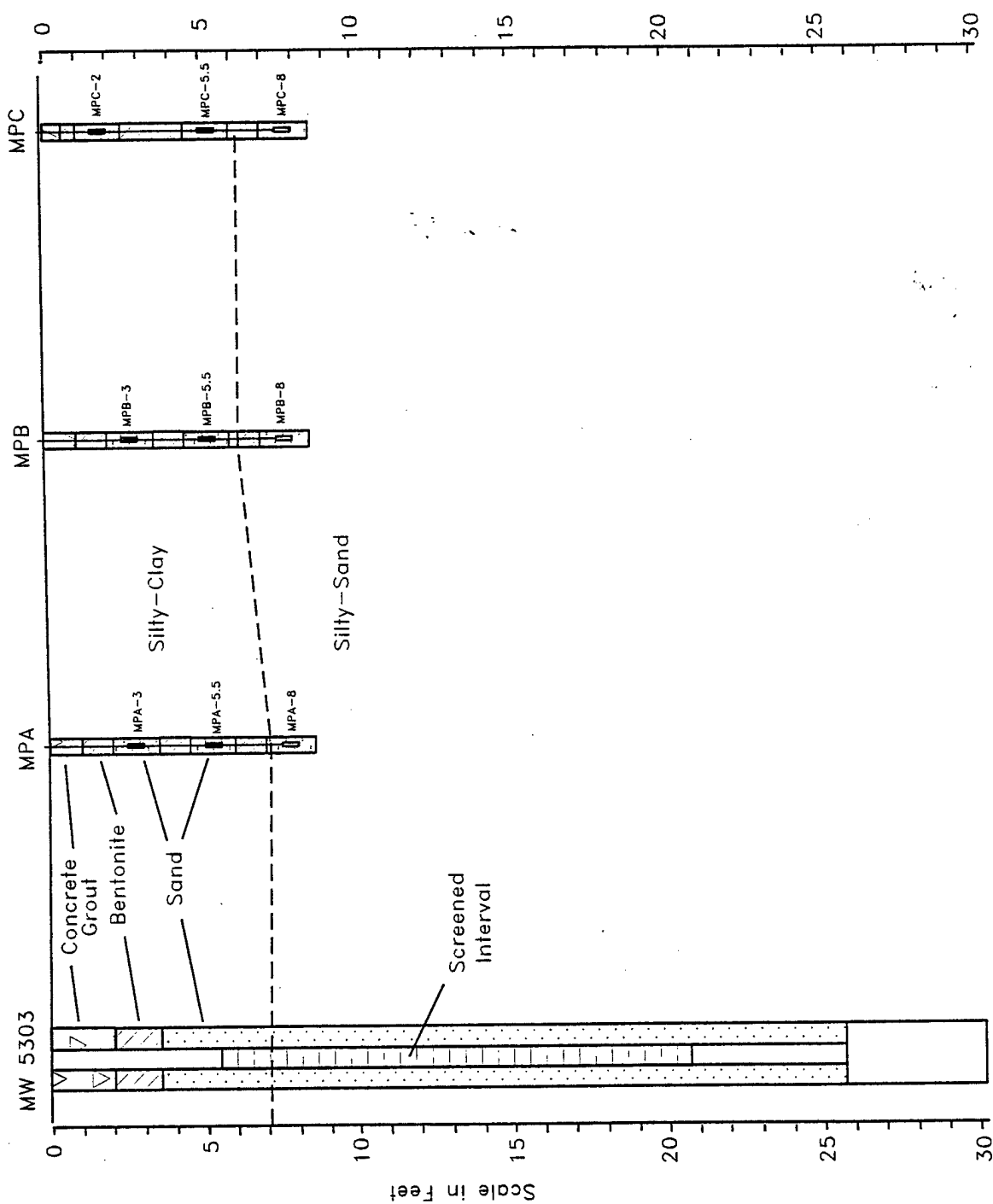


Figure 3. Biosurper Short-Term Pilot Test Monitoring Point Installation Detail



ft), JFSA-1-MPC-2 (7.5-8 ft), and JFSA-1-MPC-3 (8-8.5 ft). The samples were placed in insulated coolers containing "blue ice." Chain-of-custody records and shipping papers were completed, and the samples were sent to Alpha Analytical, Inc. in Sparks, Nevada by overnight air express. The samples were analyzed for BTEX; TPH; alkalinity; pH; moisture content; total Kjeldahl nitrogen; total phosphorous and total iron; density; porosity; and grain size distribution.

### 3.4 Soil Gas Sampling and Analyses

After installation of the monitoring points, initial soil gas measurements were taken with a GasTech brand O<sub>2</sub>/CO<sub>2</sub> meter and a GasTech brand TraceTechtor hydrocarbon meter. The initial soil gas compositions are shown in Table 1.

**TABLE 1. INITIAL SOIL GAS COMPOSITIONS AT TRAVIS AIR FORCE BASE IN JFSA-1**

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppm)
MPA	3.0	4.0	9.0	> 20,000
	5.5	0.0	11.0	> 20,000
	8.0	3.0	10.0	> 20,000
MPB	3.0	2.0	10.0	> 20,000
	5.5	0.0	11.0	> 20,000
	8.0	0.0	12.0	> 20,000
MPC	2.5	6.0	8.0	> 20,000
	5.5	0.0	12.0	> 20,000
	8.0	4.0	10.0	> 20,000

### 3.5 System Shakedown

The bioslurping pilot test system is a trailer-mounted mobile unit. The vacuum pump, oil/water separator, and required support equipment were carried to the test location on the trailer. The trailer was located near well #5303.

The well cap on well #5303 was replaced with a compression-type seal with a hole so that the drop tube could be lowered into the well. The drop tube was attached to the vacuum pump.



Different configurations of the compression seal and the placement depth for the dip tube allow operation in the bioslurping mode, simulations of skimmer pumping, or drawdown pumping as described in Sections 3.7, 3.6, and 3.9, respectively.

A brief startup test of the system was performed prior to the LNAPL recovery testing to ensure that all the system components were working properly. The system checklist is shown in Appendix A. All site data and information for the field testing were recorded in a field notebook and then transcribed onto the pilot test data sheets shown in Appendix B.

### 3.6 Skimmer Simulation Recovery Test

On January 12, 1995, the skimmer simulation recovery test was started. The oil/water interface was first measured with the oil/water interface probe. The initial conditions for the skimmer test are shown in Table 2.

TABLE 2. INITIAL CONDITIONS IN WELL #5303 FOR THE SHORT-TERM BIOSLURPER TEST

Test	Test Start	Fuel Depth (ft)	Water Depth (ft)	Fuel Thickness (ft)
	Date, <i>time</i>			
Skimmer Pump Test	January 12, 1995	8.30	8.70	0.40
Bioslurper Test	January 14, 1995	8.16	8.20	0.04
Drawdown Pump Tests	January 23, 1994	8.16	8.20	0.04

*Test end date, Time*

15 hrs

27 hrs

The pump used for the skimmer test was an Atlantic Fluidics Model A100, which is a 7.5-hp liquid ring pump. A diagram showing the configuration of the well and slurper tube for the skimmer simulation recovery test is shown in Figure 4. For the skimmer simulation recovery test the extraction tube was set at the LNAPL/groundwater interface with the wellhead open to the atmosphere at the compression seal. Prior to the start of the test, the liquid ring pump and the oil/water separator (OWS) were primed with groundwater, to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed and the liquid ring pump was then started to begin the skimmer test. The test was operated continuously for 44.5 h. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the skimmer simulation recovery test.



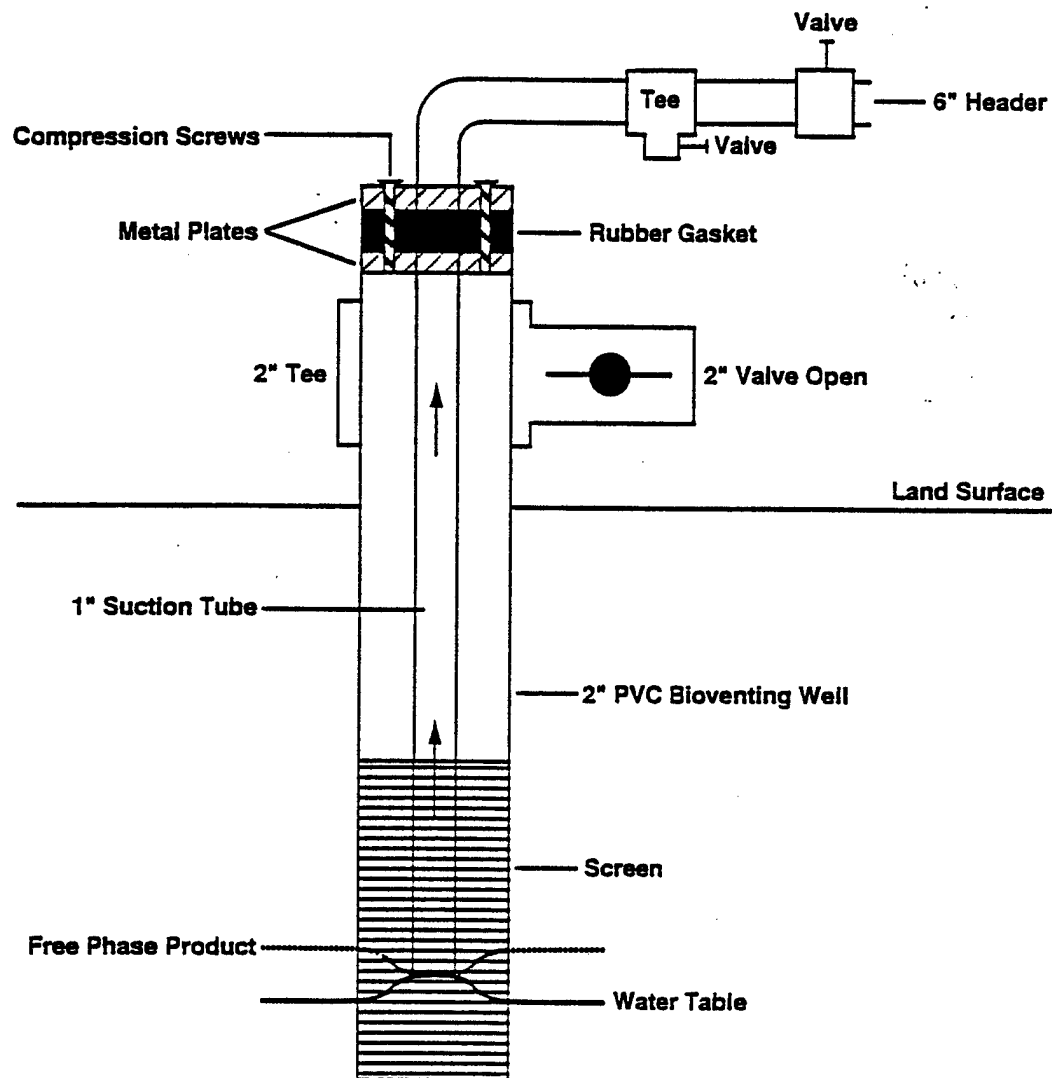


Figure 4. Slurper Tube Placement for the Skimmer Simulation Recovery Test



### 3.7 Bioslurper (Vacuum-Enhanced) Recovery Test

Upon the completion of the skimmer simulation recovery test, preparations were made to begin the vacuum-enhanced (bioslurper) recovery test. Approximately 15 hours passed between the shutdown of the skimmer test and the start of the bioslurper test. First, the oil/water interface in extraction well #5303 was measured again. The initial fluid levels in well #5303 are shown in Table 2. The extraction tube was again placed at the LNAPL/groundwater interface just as it was in the skimmer pump test. However, the vents in the compression seal were closed to allow the vacuum pump to establish a vacuum in the well. A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The same pump used for the initial bioslurper test was an Atlantic Fluidics A100 (7.5 hp). The configuration of the well and slurper tube for the vacuum-enhanced pump test is shown in Figure 5. For this test all product and groundwater flow totalizers were zeroed and reset, so that the groundwater extraction and LNAPL recovery rates could be quantified accurately. The liquid ring pump was then started to begin the bioslurper pump test. The test was started on January 14, 1995 and operated continuously for 15.5 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test.

Due to the lack of free-product recovery during the first 15 hours of vacuum-mediated extraction, the drop tube was lowered to a depth of 18 in. below the oil/water interface measured on January 15, 1995. The configuration of the rest of the system remained unchanged between the bioslurper tests with the drop pipe at the oil/water interface and 18 in. below it. This second vacuum-enhanced test was started on January 17, 1995. During the second vacuum-mediated test, pump problems resulted in the shutdown of the system for 21 hrs between January 18, 1995 and January 19, 1995. On January 19, the system was restarted using an Atlantic Fluidics Model A100 liquid ring pump (3.5 hp). Again, all other components of the system remained the same and method of data collection was unchanged.

### 3.8 Soil Gas Permeability Testing

The air permeability test data were collected during the vacuum-enhanced pumping (bioslurping) operation. Prior to establishing a vacuum in the extraction well, the initial soil gas pressures from the three monitoring points were recorded. The start of the bioslurping test created a pressure drop in the extraction well which was the starting point for the soil gas permeability testing.



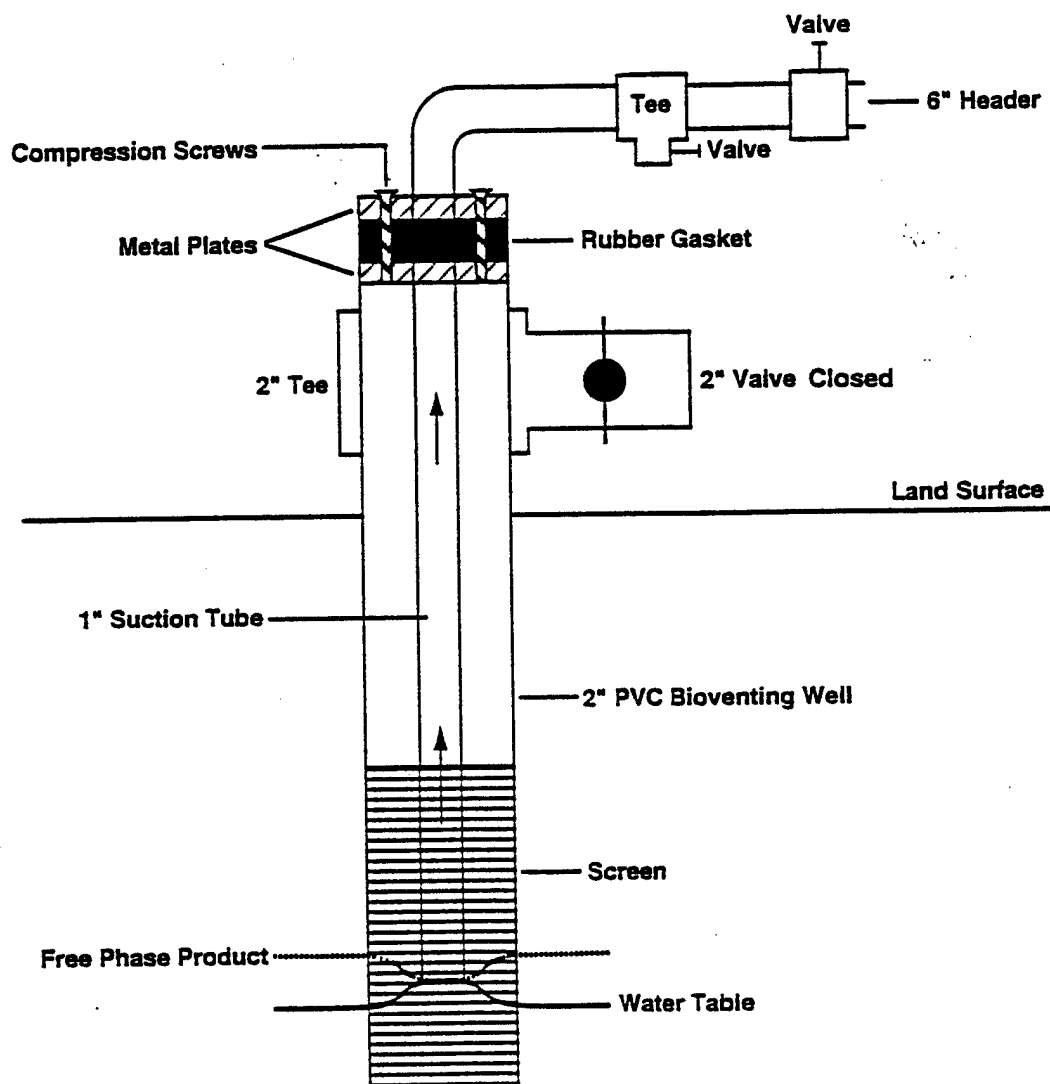


Figure 5. Slurper Tube Placement for the Bioslurper (Vacuum-Enhanced) Recovery Test



Soil gas pressures were measured in each of the three monitoring points at all depths to track the rate of outward propagation of the pressure drop from the extraction well. Soil gas pressure data were collected frequently during the first 60 minutes of the test. After the first 60 minutes, the data were collected less frequently, because of the rate of the pressure change. The soil gas pressures were recorded throughout the bioslurper pump test to determine the bioventing radius of influence.

### 3.9 Drawdown Pump Test

After the 4 days of testing in the bioslurper pump mode with the drop tube at 18 in. below the oil/water interface, the test was stopped and preparations were made for the drawdown pump test. The vents on the compression seal were again opened so that the well was open to the atmosphere. Approximately 27 hours passed between the end of the vacuum-enhanced test and the start of the first drawdown test. The drop tube was left at 18 in. below the oil/water interface for the first 24 hours of this test and then was lowered to 30 in. below the interface measured on January 15, or 10.7 ft below ground surface (bgs) for the remaining 24 hours of the test. This tube placement creates a cone of depression in the water table around the extraction well and induces LNAPL flow toward the extraction well. A diagram showing the general configuration of the drawdown pump test is depicted in Figure 6. Initial conditions for the drawdown pump test are shown in Table 2. The drawdown test with the drop tube at 9.7 ft bgs was run for 12 hours, and the drawdown test with the drop tube at 10.7 ft bgs was run for 24 hours. Before each of the drawdown tests, the LNAPL and groundwater flow totalizers were reset to determine the efficiency of the product recovery with the bioslurper in the drawdown mode. The LNAPL recovery rate and groundwater extraction rate were quantified over time.

### 3.10 In Situ Respiration Testing

Air containing approximately 1% helium was injected into three of the monitoring points for approximately 24 hours, beginning on January 22, 1995. The setup for the in situ respiration test is described in the *Bioventing Test Plan and Technical Protocol* (Hinchey et al., 1992). The pump used for the air and helium injection was a ½-hp diaphragm pump. Air and helium were injected through the following monitoring points: MPA-5.5 ft, MPB-8.0 ft, and MPC-5.0 ft. After the air/helium injection was ceased, the respiration gases were monitored periodically. The respiration test was terminated on January 26, 1994.



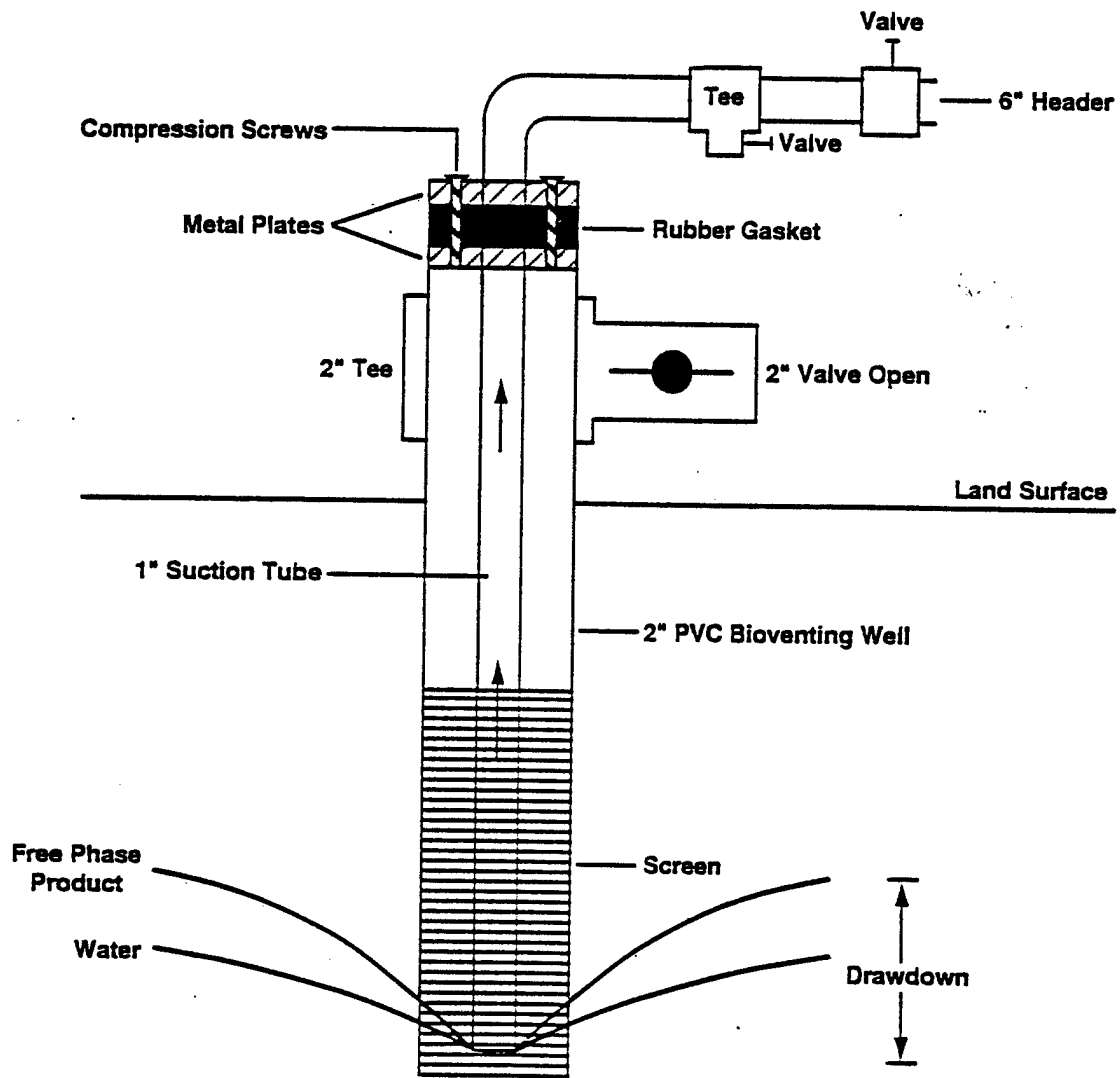


Figure 6. Slurper Tube Placement for the Drawdown Simulation Recovery Test



Helium concentrations were measured during the in situ respiration test to quantify soil gas movement around the monitoring points. Any helium loss over time is directly attributable to either diffusion through the soil or leakage. If a rapid drop in helium concentration is observed it is usually an indication of leakage through the monitoring point. A gradual loss of helium over time indicates gas transport by diffusion. When the oxygen concentration decreases faster than the helium concentration, the loss of oxygen is attributed to biological degradation of hydrocarbons (unless the soil chemical oxygen demand is unusually high). The decrease in oxygen concentration can be used to determine the biodegradation rate in terms of mg as a hexane equivalent per kg of soil per day.

### 3.11 Slug Testing

The slug tests were performed at the short-term pilot test area on January 22, 1995. Slug testing was performed in the extraction well used for the pilot testing, well #5303. The results of the slug tests help quantify the hydrogeologic properties of the formation near the test well. The slug tests were done by creating an instantaneous change in head within the well using a PVC slug. The instruments used to record the data produced during the slug test were a pressure transducer (Model PDX-260) and a Hermit Model SE2000C data logger both of which are manufactured by In Situ, Inc. The slug test was done by lowering the 3-foot-long PVC slug down the well to displace the water. After equilibrium between the water level in the well and the aquifer was reached, the slug was quickly removed and the Hermit data logger was started. The data logger records the head pressure above the transducer, and the test is stopped once the amount of head above the transducer has reached its original level (i.e., equilibrium level).

## 4.0 RESULTS

This section documents the results of the preliminary site characterization, the comparative LNAPL recovery pumping studies, and other supporting tests conducted at the TAFB site.

### 4.1 Soil Sample Analyses

Table 3 shows the BTEX and TPH content measured in soil samples from the short-term pilot test area. The laboratory analytical report for the soil samples is shown in Appendix C. The concentrations of the BTEX compounds in the soil samples range from 8,100 mg/kg for benzene to



370,000 mg/kg for total xylenes. The purgeable TPH concentration in the soil samples ranged from 2,100 to 15,000 mg/kg. The sieve analyses of the soil samples (see Table 4) indicate that site soil is composed of about 50% sand, 25% silts, and 25% clay. The results of the soil chemistry analyses are summarized in Table 5.

**TABLE 3. SOIL SAMPLE ANALYSES FROM TRAVIS AFB, SOIL SAMPLES TAKEN FROM MONITORING POINT A AT BIOSLURPER TEST SITE**

Depth (ft)	Parameter	Detection Limit (mg/kg)	Concentration <sup>(a)</sup> (mg/kg)
MPA-7.0-7.5 ft	TPH (Purgeable)	10	12,000
	Benzene	0.02	63
	Toluene	0.02	220
	Ethylbenzene	0.02	80
	Total Xylenes	0.02	370
MPC-7.0-7.5 ft	TPH (Purgeable)	200	4,200
	Benzene	0.4	22
	Toluene	0.4	84
	Ethylbenzene	0.4	33
	Total Xylenes	0.4	150
MPC-7.5-8.0 ft	TPH (Purgeable)	200	15,000
	Benzene	0.4	8.1
	Toluene	0.4	29
	Total Xylenes	0.4	55
	Ethyl Benzene	0.4	12
MPC-8.0-8.5 ft	TPH (Purgeable)	200	2,100
	Benzene	0.4	9
	Toluene	0.4	38
	Total Xylenes	0.4	80
	Ethyl Benzene	0.4	18

(a) Analysis performed by Alpha Analytical, Inc.



**TABLE 4. SOIL SIEVE ANALYSIS FROM TRAVIS AFB, SOIL SAMPLES TAKEN FROM MONITORING POINT AT BIOSLURPER PILOT TEST SITE<sup>(a)</sup>**

	Sand (%)	Silt (%)	Clay (%)
MPA-7.0-7.5 ft	38	33	29
MPC-7.0-7.5 ft	51	24	25
MPC-7.5-8.0 ft	54	22	24
MPC-8.0-8.5 ft	54	23	23

(a) Analysis performed by Alpha Analytical, Inc.

**TABLE 5. SOIL SAMPLE ANALYSIS FROM TRAVIS AFB, SOIL MAKEUP FROM MONITORING POINT A AT BIOSLURPER SITE<sup>(a)</sup>**

	MPA-7.0-7.5 ft	MPC-7.0-7.5 ft	MPC-7.5-8.0 ft	MPC-8.0-8.5 ft
pH	9.56	9.53	7.75	7.40
Moisture Content (%)	15.2	14.5	14.5	12.2
Nitrate-N ( $\mu\text{g/g}$ )	3.6	2.8	2.0	2.2
Kjeldahl-N ( $\text{mg/g}$ )	3.3	4.7	4.0	5.3
Phosphorous-total ( $\mu\text{g/g}$ )	0.94	1.48	5.61	6.17
Nitrogen-total ( $\text{mg/g}$ )	3.3	4.7	4.0	5.3
Iron-total ( $\text{mg/g}$ )	36	30	29	31
Density ( $\text{g/cm}^3$ )	1.50	1.56	1.32	1.61
Porosity (%)	43.4	41.1	50.2	39.2

(a) Analyses performed by Alpha Analytical, Inc.

#### 4.2 Pilot LNAPL Recovery Test Results

The skimmer pump, bioslurper pump, and drawdown pump test data are summarized in Table 6. LNAPL recovery versus time is plotted for each test configuration on Figure 7, except for the bioslurper mode of operation with the dip tube placed at the oil/water interface. No fuel was recovered during this test because pump failure occurred and the vacuum placed on the well with the



TABLE 6. BIOSLURPER PILOT STUDY AT TRAVIS AFB, FAIRFIELD, CA, EXTRACTION WELL #5303

Data Item	Skimmer Pump Test		Bioslurper Test at Oil/Water Contact <sup>(a)</sup>		Bioslurper Test at 18 in. Below Oil/Water Contact		Drawdown Test at 18 in. Below Oil/Water Contact		Drawdown Test at 30 in. Below Oil/Water Contact	
	1.85		0.62		4.21		1.0		2.0	
Test Duration (days)										
Medium:	LNAPL	Water	LNAPL	Water	LNAPL	Water	LNAPL	Water	LNAPL	Water
Total Recovered (gal)	0.0	75	0.0	31	0.0	14.28	3.25	293	7.53	1,147
Recovery Rate Day 1 (gal/day)	0.0	40	NA	NA	NA	540	3.25	293	3.38	486
Recovery Rate Day 2 (gal/day)	0.0	35	NA	NA	NA	353	NA	NA	4.14	661
Recovery Rate Day 3 (gal/day)	NA	NA	NA	NA	NA	428	NA	NA	NA	NA
Recovery Rate Day 4 (gal/day)	NA	NA	NA	NA	NA	345	NA	NA	NA	NA
Average Recovery Rate (gal/day)	0.0	40.5	0.0	1,912	4.65	388	3.2	293	3.76	573.5

(a) Pump failure occurred during this test.



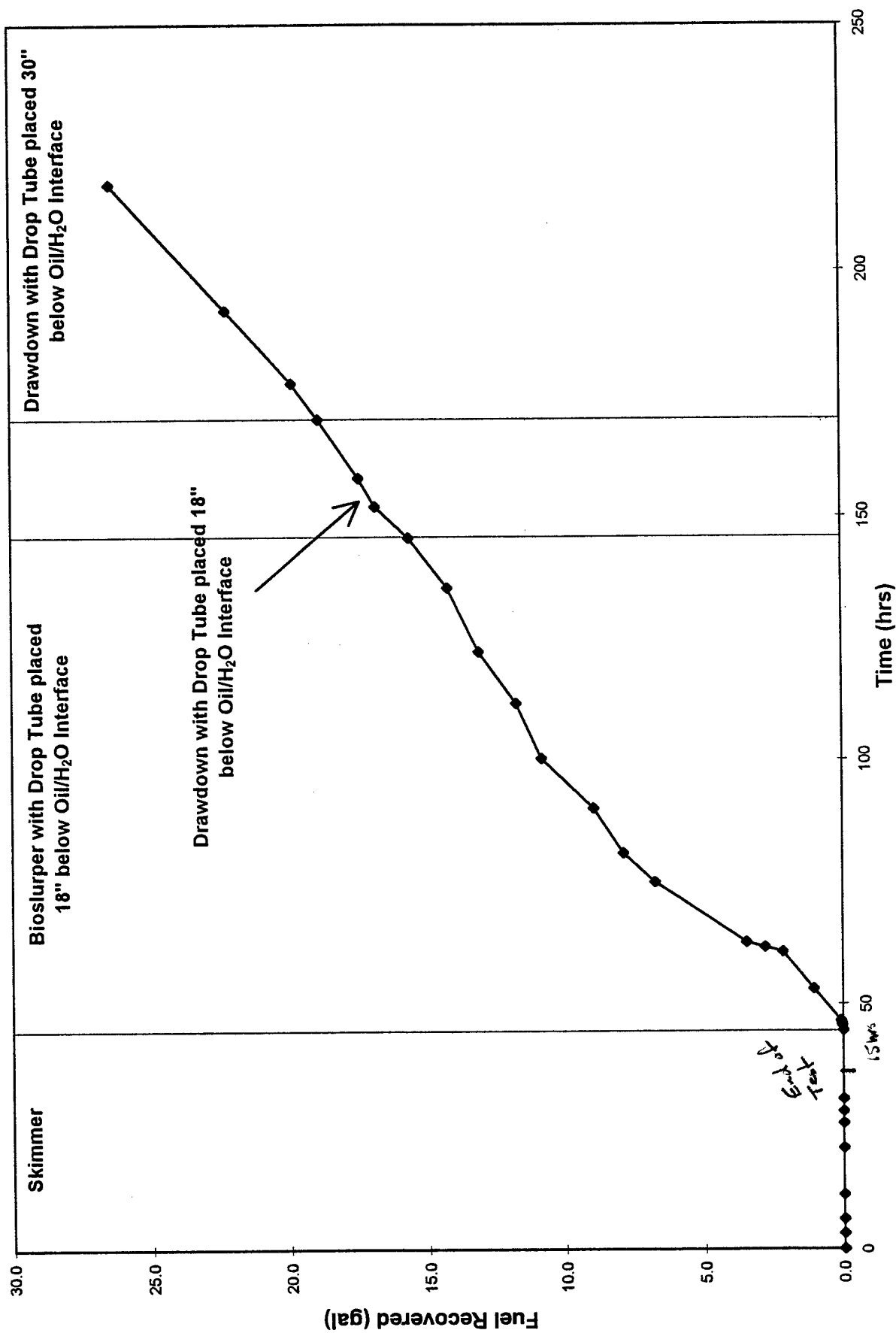


Figure 7. Total LNAPL Recovery as a Function of Time Through the Test Sequence



dip tube at the oil/water interface was insufficient to extract the floating LNAPL. Results for each test configuration are discussed below.

#### **4.2.1 Skimmer Test Results**

The bioslurper system was operated in the skimmer simulation mode for approximately 1 day (22.4 hrs). A total of 0 gal LNAPL and 75 gal groundwater were recovered during the test. Therefore, the daily recovery averages equal 0 gal/day for LNAPL and 40 gal/day for groundwater.

#### **4.2.2 Bioslurper (Vacuum-Enhanced) Test Results**

The vacuum-enhanced recovery test with the drop tube at the oil/water interface was started approximately 12 hours after the skimmer test was completed. The bioslurper test was run with the drop tube at the oil/water interface for approximately 15 hours, but due to the lack of free-product recovery, the drop tube was lowered to 18 in. below the oil/water interface. While the drop tube was at the interface, 0 gal fuel but 31 gal of water were recovered. These results are not presented in Figure 7 and were not used to calculate the average recovery rate during the bioslurper test.

After lowering the drop tube to 18 in. below the oil/water interface, the system was run in the bioslurper mode for 89 hours (3.71 days). During the vacuum-enhanced recovery configuration, 14.28 gal free product and 1,438 gal water were recovered. The average rates of free-product recovery and groundwater extraction were 3.85 gal/day and 387 gal/day, respectively.

Table 7 presents the system parameters during the bioslurper pump test over time. The table shows that the wellhead vacuum varied between 6 and 24 in. H<sub>2</sub>O throughout the bioslurper pump test. This vacuum is equivalent to creating a 6- to 24-in. cone of depression in the water table at the extraction well.

Figure 8 is a graphical representation of the fuel recovery rate during the bioslurper test, which indicates the rate of LNAPL recovery decreased rapidly after the first 2 hours of the beginning of the test. After 2 days of performing the bioslurper test the rates appear to become more constant at a rate of approximately 3 gal fuel/day.

The vapor discharge during the bioslurper test was sampled and analyzed. The vapor discharge rate for the bioslurper test was approximately 28,000 ft<sup>3</sup>/day (20 cfm). Based on the analyses and the vapor discharge rate, approximately 126 lb/day of TPH was emitted to the air during the bioslurper test. An off-gas composition measurement at the beginning of the vacuum-enhanced test indicates that the CO<sub>2</sub> and O<sub>2</sub> concentrations were near ambient.



TABLE 7. SYSTEM PARAMETERS DURING THE VACUUM-ENHANCED MODE OF THE TEST.  
INCLUDED ARE DATA ON THE WELLHEAD VACUUM. 18' below

Date/Time		Run Time (min)	Vapor Extraction			Pump Stack Temp. (°C)	Pump Head Vacuum (in Hg)	Slurper Vacuum (in H <sub>2</sub> O)	Tank Temp. (°C)	Tank Press. (psi)	Field DV # ?	Stack O <sub>2</sub> (%)	Stack CO <sub>2</sub> (%)
month/ day/ year	hr:min		Stack Pressure (in H <sub>2</sub> O)	Carbon Drums (in H <sub>2</sub> O)	Flow Rate (scfm)								
1/17/95	17:40	0	—	—	—	—	23.0	17.0	—	—	5,800.0	21.0	0.6
1/17/95	18:40	60	0.5	—	20.00	14.7	17.5	19.00	—	—	—	—	—
1/17/95	19:40	120	0.5	—	20.00	—	17.0	20.0	—	—	—	—	—
1/17/95	21:45	245	0.3	—	20.00	13.7	17.0	20.0	—	—	—	—	—
1/18/95	8:00	860	0.3	—	20.00	9.1	16.5	—	—	—	8,000.0	—	—
1/18/95	13:57	1,217	0.6	—	20.00	17.2	17.0	20.0	—	—	—	—	—
1/19/95	14:45	2,705	0.0	—	20.00	—	6.0	7.0	—	—	—	—	—
1/19/95	0:00	1,820	—	—	—	—	7.0	—	—	—	—	—	—
1/20/95	10:45	3,905	0.5	—	20.00	25.3	8.0	8.0	26.8	—	—	—	—
1/20/95	22:00	4,580	0.3	—	20.00	—	10.0	10.0	—	—	—	—	—
1/21/95	8:30	5,210	0.3	—	20.0	25.8	10.0	7.0	27.5	—	—	—	—
1/21/95	21:45	6,005	—	—	20.0	26.0	11.0	11.0	27.7	—	—	—	—



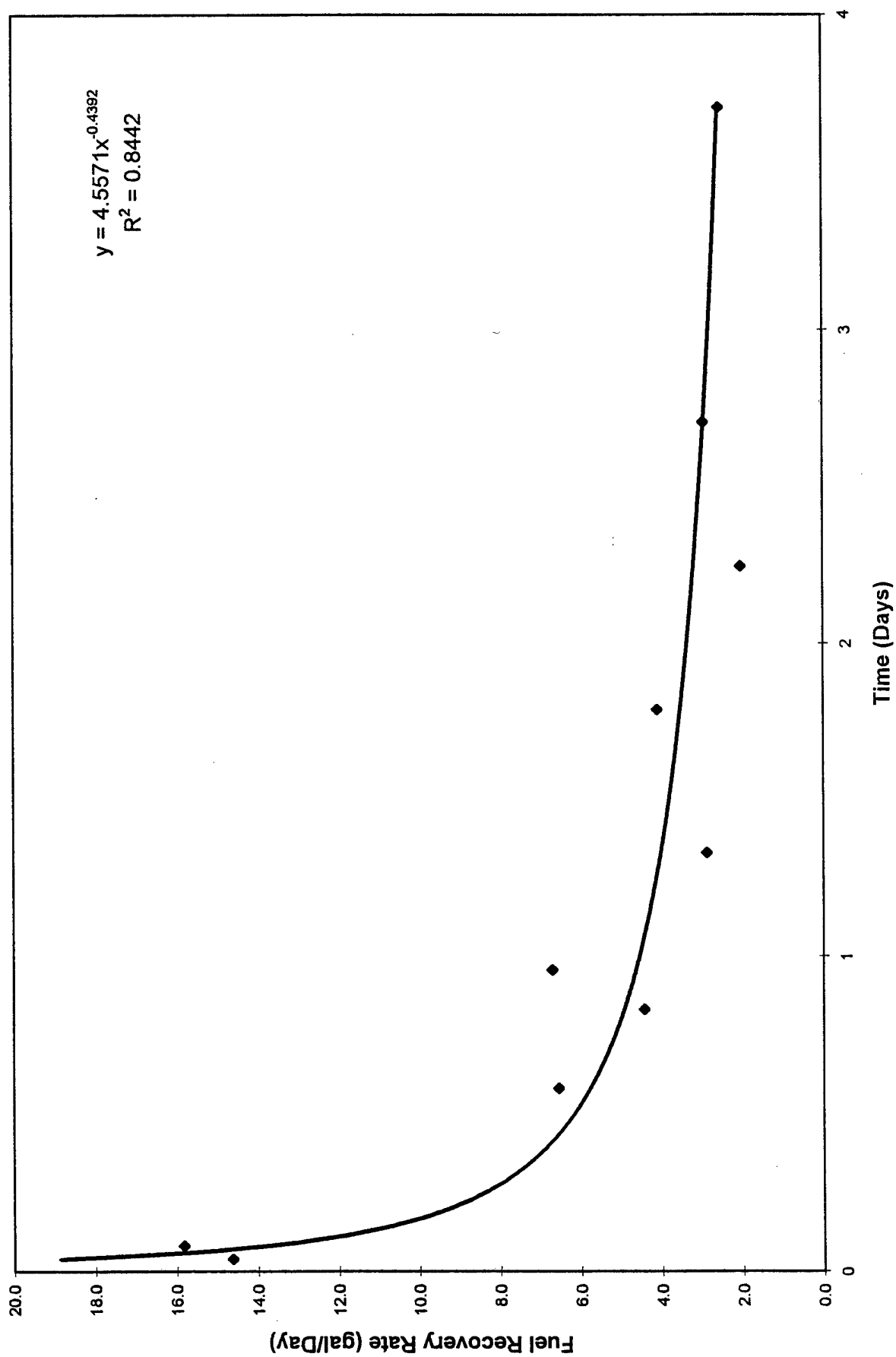


Figure 8. Free-Product Recovery Rate Throughout the Bioslurper Test



#### **4.2.3 Drawdown LNAPL Recovery Test**

The drawdown recovery test was performed with the drop tube at 18 in. below the oil/water interface and at 30 in below the oil/water interface. The test with the drop tube at 18 in. below the interface was used as a comparison for the vacuum-enhanced test with the drop tube set at the same level. The drawdown test with the drop tube 18 in. below the oil/water interface was run for 24 hours and the drawdown test with the drop tube placed at 30 in. below the interface was run for 48 hours.

The total recovery with the drop tube at 18 in. below the interface was 3.25 gal of free product and 293 gal groundwater. Therefore, the rate of recovery is 3.25 gal/day for free product and 293 gal/day for groundwater. The recovery rate of free product remained nearly constant during the test.

While the drop tube was at 30 in. below the interface, 7.53 gal free product was recovered and 661 gal water was extracted. The average rate of recovery was 3.76 gal/day and 573 gal/day for free product and water, respectively.

#### **4.3 LNAPL, Groundwater Discharge, and Vapor Discharge Analyses**

During the operation of the bioslurper pump test, water and fuel samples were collected. The free product samples were collected from the extraction well before starting the vacuum-enhanced recovery test, and the water samples were collected from the water discharge pipe leading from the oil/water separator. The analyses of these fuel and water samples were performed by Alpha Analytical, Inc. The fuel composition is shown in Tables 8 and 9. The contaminant concentration in the water from the oil/water separator is displayed in Table 10. In addition, vapor samples were collected from the bioslurper system vapor discharge stack. The analysis of the vapor samples was done by Air Toxics, Inc. The results from the vapor discharge samples are presented in Table 11. The laboratory analytical reports for all analyses are presented in Appendix C.

#### **4.4 Slug Test Results**

Figure 9 presents the data from the slug tests performed on well #5303. The raw data and replicate slug test data and results are shown in Appendix F. The hydraulic conductivity of the area surrounding well #5303 based on the results of the slug tests was 0.23 ft per day. As stated previously, the soils near the extraction well are composed of clay-rich silts and sands. The results from the slug test can be used to determine the efficiency of the bioslurper system operating in soils



**TABLE 8. BTEX FUEL ANALYSIS FROM TRAVIS AFB RECOVERED FUEL FROM BIOSLURPER PILOT TEST ON WELL #5303**

COMPOUND	METHOD	DETECTION LIMIT ( $\mu\text{g/kg}$ )	CONCENTRATION <sup>(a)</sup> ( $\mu\text{g/kg}$ )
Benzene	8240	490	2,000
Toluene	8240	490	11,000
Ethylbenzene	8240	490	8,000
Total Xylenes	8240	490	35,000

(a) Analyses performed by Alpha Analytical, Inc.

**TABLE 9. C-RANGE COMPOUNDS FROM FUEL ANALYSIS FROM TRAVIS AFB RECOVERED FUEL FROM BIOSLURPER PILOT TEST ON WELL #5303**

C-RANGE COMPOUNDS	METHOD	PERCENTAGE OF TOTAL <sup>(a)</sup>
C9 and <	GC/FID	47.25
C9	GC/FID	21.55
C10	GC/FID	13.88
C11	GC/FID	6.54
C12	GC/FID	3.80
C13	GC/FID	3.03
C14	GC/FID	2.15
C15	GC/FID	0.95
C16	GC/FID	0.37
C17	GC/FID	0.47

(a) Analysis performed by Alpha Analytical, Inc.



**TABLE 10. GROUNDWATER SAMPLE ANALYSIS FROM TRAVIS AFB,  
GROUNDWATER SAMPLE TAKEN FROM OIL/WATER  
SEPARATOR WATER DISCHARGE STREAM  
DURING BIOSLURPER PILOT TEST**

SAMPLE	DAY OF TEST	PARAMETER	DETECTION LIMIT (mg/L)	CONCENTRATION (mg/L) <sup>(a)</sup>
JFSA-1-WS-1	1	TPH (Purgeable)	5.0	11
		Benzene	0.01	0.91
		Toluene	0.01	1.8
		Ethylbenzene	0.01	0.51
		Total Xylenes	0.01	2.80
JFSA-1-WS-2	2	TPH (Purgeable)	5.0	16
		Benzene	0.01	1.10
		Toluene	0.01	2.50
		Ethylbenzene	0.01	0.78
		Total Xylenes	0.01	4.30
JFSA-1-WS-3	4	TPH (Purgeable)	5.0	20
		Benzene	0.01	1.00
		Toluene	0.01	2.10
		Ethylbenzene	0.01	0.71
		Total Xylenes	0.01	4.00
JFSA-1-WS-4	4	TPH (Purgeable)	5.0	20
		Benzene	0.01	1.10
		Toluene	0.01	2.50
		Ethylbenzene	0.01	0.81
		Total Xylenes	0.01	4.40

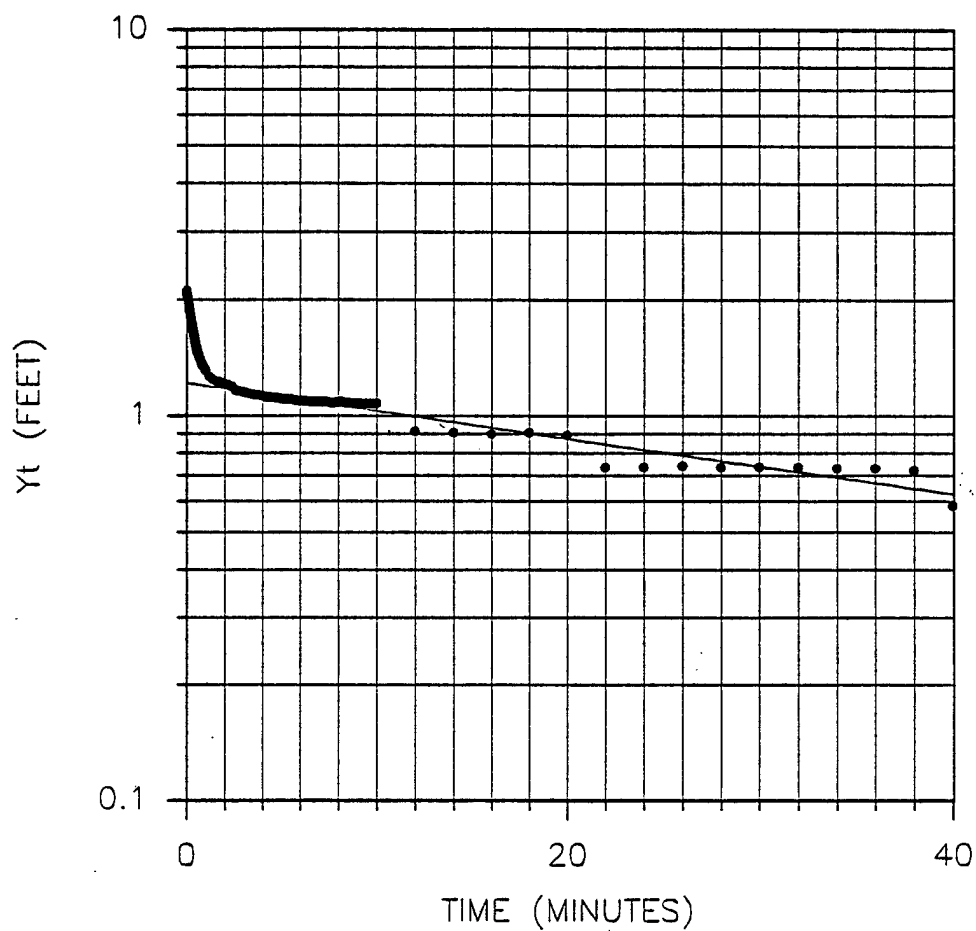
(a) Analyses performed by Alpha Analytical, Inc.



**TABLE 11. DISCHARGE VAPOR ANALYSIS FROM TRAVIS AFB BIOSLURPER  
PILOT TEST; SAMPLES TAKEN FROM BIOSLURPER STACK**

SAMPLE	DAY OF TEST	PARAMETER	METHOD	DETECTION LIMIT (mg/L)	CONCENTRATION (ppmv)
JFSA-1-OGS-1	1	TPH (as jet fuel)	GC/FID	16	10,000
		Benzene	GC/FID	1.6	93
		Toluene	GC/FID	1.6	200
		Ethylbenzene	GC/FID	1.6	260
		Total Xylenes	GC/FID	1.6	64
JFSA-1-OGS-2	3	TPH (as jet fuel)	GC/FID	16	10,000
		Benzene	GC/FID	1.6	96
		Toluene	GC/FID	1.6	190
		Ethylbenzene	GC/FID	1.6	59
		Total Xylenes	GC/FID	1.6	230
JFSA-1-OGS-3	1	TPH (as jet fuel)	GC/FID	16	9,200
		Benzene	GC/FID	1.6	79
		Toluene	GC/FID	1.6	180
		Ethylbenzene	GC/FID	1.6	56
		Total Xylenes	GC/FID	1.6	230
JFSA-1-OGS-4	3	TPH (as jet fuel)	GC/FID	16	14,000
		Benzene	GC/FID	1.6	130
		Toluene	GC/FID	1.6	290
		Ethylbenzene	GC/FID	1.6	79
		Total Xylenes	GC/FID	1.6	310





Bouwer and Rice Slug Test Analysis					
Well 5303 - Replicate #1					
D =	37	ft			
L =	15	ft			
H =	12.39	ft			
rw =	1.25	ft			
rc =	0.5	ft			
L/rw =	12.00			ln Re/rw =	1.05
A =	2			Re =	3.56
B =	1.25				
t =	18	min		K =	0.20 ft/day
Yt =	0.9	ft			
Yo =	1.2	ft			

Figure 9. Level Variation During an Example Slug Test in Well #5303



with relatively low hydraulic conductivities. These results will be used to compare the efficiency of the bioslurping at this site with bioslurping in other sites that possess different lithologies and hydraulic conductivities.

#### 4.5 Bioventing Analyses

##### 4.5.1 Soil Gas Permeability and Radius of Influence

The raw data collected during the soil gas permeability test are shown in Appendix D. Using the steady-state method for calculating soil gas permeability, a soil gas permeability of 0.16 darcys was determined.

The radius of influence is calculated by plotting the log of the pressure change at a specific monitoring point versus the distance from the extraction well. The radius of influence would then be the distance where 0.1 in. of H<sub>2</sub>O can be measured. Therefore, the radius of influence based on these specifications is 55.3 ft (see Figure 10).

##### 4.5.2 In Situ Respiration Test

The raw data collected during the in situ respiration test are compiled in Appendix E. Figure 11 illustrates the variation of oxygen, carbon dioxide, and helium in the soil gas during the in situ respiration test. A summary of the oxygen utilization and carbon dioxide production rates and the corresponding biodegradation rates is shown as Table 12. The biodegradation rates measured at this site ranged from 61 to 82 mg (hexane equivalents)/kg (soil)/day based on oxygen utilization.

**TABLE 12. OXYGEN UTILIZATION RATES DURING THE IN SITU RESPIRATION TEST AT TRAVIS AFB**

MONITORING POINT	OXYGEN UTILIZATION RATE (%/hr)	BIODEGRADATION RATE (mg/kg/day)
MPA-5.5	3.14	61
MPB-8	3.14	61
MPC-5.5	4.28	82

Loss of helium was insignificant at all monitoring points, indicating that the monitoring points were well sealed and that the oxygen depletion observed was a result of biodegradation.



## Radius of Influence

Site Name Travis AFB

Date: 1/17/95

Time (min.)	Air Flow (cfm)	Vacuum (inches of water)													
		green	blue	red	green	blue	red	blue	black	clear	orange	yellow	blue	green	red
0.00		0.00	0.00	0.00	0.00	0.00	0.00								
9.00		0.00	0.14	0.01	0.03	0.09	0.00								
31.00		0.00	0.34	0.33	0.04	0.18	0.01								
60.00		0.00	0.55	0.55	0.13	0.35	0.22								
105.00		0.00	0.70	0.70	0.15	0.40	0.30								
120.00		0.00	0.70	0.65	0.15	0.40	0.30								
240.00		0.55	0.95	0.95	0.16	0.50	0.40								
Distance (ft)		10	10	10	30	30	30								

R<sub>i</sub>: 55.28 ft

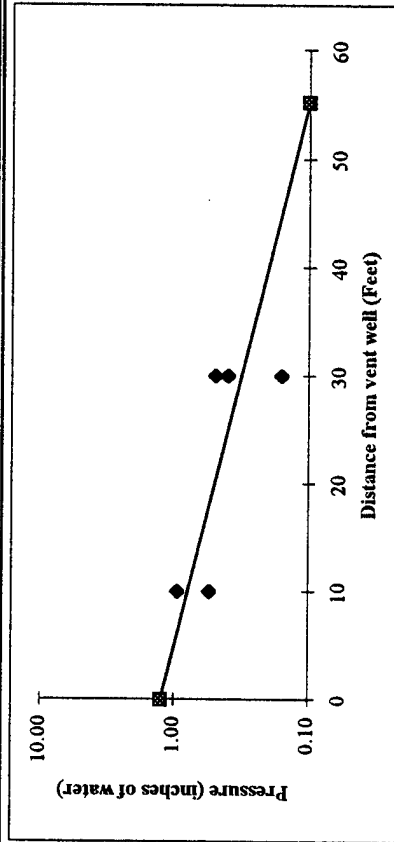


Figure 10. Soil Gas Pressure as a Function of Distance



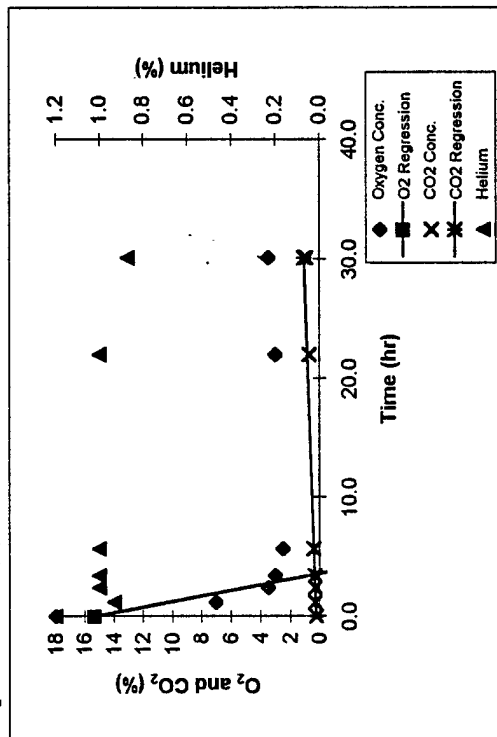
# Utilization Rates (3)

Date: 1/23/95  
 Site Name: Travis AFB  
 Monitoring Point: MPC  
 Depth of M.P. (ft): 5.5

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
1/23/95 11:05	0.0	18.00	0.20	1.20
1/23/95 12:15	1.2	7.00	0.30	0.93
1/23/95 13:30	2.4	3.50	0.30	1.00
1/23/95 14:30	3.4	3.00	0.30	1.00
1/23/95 16:45	5.7	2.50	0.40	1.00
1/24/95 9:05	22.0	3.00	0.70	1.00
1/24/95 17:10	30.1	3.50	0.90	0.87

## O<sub>2</sub> Utilization Rate

K<sub>0</sub> 0.071 %/min  
 4.264 %/hr  
 102.340 %/day



Regression Lines	O <sub>2</sub>	CO <sub>2</sub>
Slope	-4.2642	0.0264
Intercept	15.3373	0.2288
Determination Coef.	0.8240	0.6164
No. of Data Points.	4	4

Figure 11. Soil Gas Composition Variation During an In Situ Respiration Test



## 5.0 DISCUSSION OF RESULTS

Free-product recovery was limited to the configurations of the bioslurper system that had the drop tube extending below the oil/water interface. In the skimmer test and the bioslurper test with the drop tube placed at the oil/water interface, no free product was recovered and the amount of water extracted was much less than in tests run with the drop tube placed below the interface. Heavy rains during the tests affected the level of the water table near the site, which appeared to prevent the recovery of free product during the skimmer and bioslurper tests with the drop tube at the oil/water interface. It was decided that the water table needed to be lowered in order to recover free product. Therefore, the drop tube was placed at 18 in. below the oil/water interface for the bioslurper test.

The appearance of free-product recovery when the drop pipe is lowered to below the interface is attributed to the cone of depression that is formed by decreasing the water level within the extraction well. The results demonstrate that the presence of a vacuum within the extraction increases the average rate of free-product recovery compared to a nonvacuum drawdown extraction. During the first day of vacuum-enhanced extraction the fuel recovery rate computed to 6.78 gal/day. This was significantly higher than the fuel recovery rate for the drawdown modes of LNAPL recovery. Also, at the end of the 4-day bioslurper test, the recovery rate (3.85 gal/day) was still greater than either drawdown tests' recovery rates (3.20 gal/day at 9.7 bgs, 3.76 gal/day at 10.7 bgs). In addition, the vacuum-enhanced pilot test increased the oxygen concentrations in the vadose zone to above oxygen-limited conditions, or to greater than 5% O<sub>2</sub>. In situ respiration tests indicated an average biodegradation rate of 68 mg/kg/day would be produced if oxygen concentrations were not limited.

Installation of the bioslurper system would likely enhance free product removal at JFSA-1 at Travis AFB. Additionally, in situ biodegradation of vadose zone contamination would be promoted by the increase in oxygen concentrations in the vadose zone. The feasibility of implementing a bioslurper system at Travis AFB is dependent on regulations for the discharge of vapor and the disposition of the extracted groundwater.

## 6.0 EXTENDED TESTING AT TRAVIS AFB

Currently, plans are being made to initiate the extended bioslurper test at Travis AFB that will continue for 1 month after the startup date. Arrangements are being made to connect the bioslurper system to electric power at the site and to connect wells #5302 and WS001V03 to the bioslurper



extraction system. The primary purpose of the extended test is to optimize system operation for the expanded-scale bioslurping. Specific concerns that will be addressed during the system optimization include proper placement of the drop tube and disposition of the vapor and aqueous discharge from the bioslurper system.

Alternatives to direct release of the extracted vapors are reinjection or destruction in an internal combustion engine. The site-specific test plan contains the specific arrangement and the benefits of both these treatment methods. Based on data from the short-term pilot test, it is estimated that 126 lb/day of TPH will be produced during operation of the bioslurper. Reinjection may prove to be a viable option because of the large biodegradation rates and the relatively large radius of influence. Oxygen utilization rates averaged 3.52%/hour for the three monitoring points used in the respiration test; the radius of influence is 55 feet.

If the extracted vapors are reinjected into the ground, the configuration of the bioslurper system will be such that surface emissions of vapors will be minimized and the subsurface oxygen distribution will be maximized for bioventing. The bioslurper system will be set up to extract from the free-product recovery wells (FPRWs) on site. The stack vapor will be plumbed to reinject vapor into an existing vapor monitoring well. A pressure/vapor monitoring point will be installed on the reinjection well to monitor injection pressure and hydrocarbon concentrations. Most of the vapors that are reinjected will be recaptured by the bioslurper system because of the relatively large radius of influence of the bioslurper extraction wells. Such a flow pattern creates a closed system for the vapors. However, a surface emissions test will be conducted to determine the mass of hydrocarbons emitted at the surface and to confirm that hydrocarbons are in fact being treated in situ.

It is expected that approximately 0.4 gal groundwater will be extracted per minute per well. At this extraction rate, it may be feasible to discharge the groundwater directly to the sanitary sewage system. Base personnel have indicated that the charge for discharge of groundwater to the sanitary sewer will be \$0.05/gal.

## **7.0 EXPANDED TESTING AT TRAVIS AFB**

Based on the results of the extended tests, recommendations will be provided on expanded-scale testing. If expanded-scale testing is feasible, a test plan will be developed outlining specific procedures for long-term operation of the system. It is expected that all of the free-product recovery wells will be connected to the bioslurper system, and that free-product recovery will last approximately 1 year.



## 8.0 REFERENCES

Battelle. 1995. *Test Plan and Technical Protocol for Bioslurping*. Report to U.S. Air Force, Brooks AFB, Texas. January 30, 1995.

Hinchee, R.E., S.K. Ong, R.N. Miller, and D.C. Downey. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing*. Report to U.S. Air Force Center for Environmental Excellence, Brooks AFB, Texas.



**APPENDIX A**  
**SYSTEM CHECKLIST**



# Checklist for System Shakedown

Site: Travis, AFB

Date: Dec 15 '95

Operator's Initials: D.C.F. & M.P.

Equipment	Check if Okay	Comments
Liquid Ring Pump	/	pump failure occurred during bioscience test, replaced
Aqueous Effluent Transfer Pump	/	
Oil/Water Separator	/	
Vapor Flowmeter	/	
Fuel Flowmeter	/	broken used grade cylinder
Water Flowmeter	/	
Emergency Shut off Float Switch Effluent Transfer Tank	/	float switch by-passed
Analytical Field Instrumentation GasTector™ O <sub>2</sub> /CO <sub>2</sub> Analyzer ✓ TraceTector™ Hydrocarbon Analyzer ✓ Oil/Water Interface Probe ✓ Magnetic Boards ✓ Thermocouple Thermometer ✓	/	



**APPENDIX B**

**DATA SHEETS FROM THE SHORT-TERM PILOT TEST**



Depth to Tube: \_\_\_\_\_

## Fuel and Water Recovery Data

**Test Type:** Skimmer

**Operators:** Place/Foor

[illegible]



## Pumping Test Data

Site: Travis AFB  
Operators: \_\_\_\_\_  
Test Type: Skimmer

**Start Date:** 12-Jan-95  
**Start Time:** 10:55  
**Well ID:** 5303

Depth to GW (ft): \_\_\_\_\_  
Depth to Tube (ft): \_\_\_\_\_

**Depth to Fuel (ft):** \_\_\_\_\_

[illegible]



## Fuel and Water Recovery Data

Site: Travis AFB      Start Date: 1/14/95  
 Test Type: Vacuum Enhancement      Operators: Place/Foor

Date/Time (mm/dd/yr hr:min)	Elapsed Time (min)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gpm)	Avg. Rate (gpm)	Collected (gal)	Total (gal)	Rate (gpm)	Avg. Rate (gpm)
1/14/95 20:30	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1/15/95 5:00	510	0.00	0.00	0.00	0.00	25	25.00	0.05	0.05
1/15/95 10:00	810	0.00	0.00	0.00	0.00	5	30.00	0.01	0.04
1/15/95 12:00	930	0.00	0.00	0.00	0.00	5	35.00	0.01	0.04
Total Hours	15.50	Rate (GPH)	0.00			Rate (GPH)	2.26		



## Fuel and Water Recovery Data

**Site:** Travis AFB  
**Test Type:** Vacuum Enhancement

**Start Date:** 1/17/95

**Operators:** Place/Foor

Date/Time (mm/dd/yr hr:min)	Elapsed Time (hours)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gpd)	Avg. Rate (gpd)	Collected (gal)	Total (gal)	Rate (gpd)	Avg. Rate (gpd)
1/17/95 17:40	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1/17/95 18:40	1	0.61	0.61	14.64	14.64	0	0.00	0.00	0.00
1/17/95 19:40	2	0.66	1.27	7.92	15.24	64	64.00	768.00	768.00
1/18/95 8:00	14	3.28	4.55	5.62	7.80	254	318.00	435.43	545.14
1/18/95 14:00	20	1.11	5.66	1.33	6.79	132	450.00	158.40	540.00
1/18/95 17:00	23	0.84	6.50	0.88	6.78	66	516.00	68.87	538.43
1/19/95 14:45	23	0.00	6.50	0.00	6.78	0	516.00	0.00	538.43
1/20/95 0:00	32	1.08	7.58	0.81	5.69	149	665.00	111.75	498.75
1/20/95 10:45	43	1.88	9.46	1.05	5.28	145	810.00	80.93	452.09
1/20/95 22:00	54	0.93	10.39	0.41	4.62	142	952.00	63.11	423.11
1/21/95 8:30	65	1.35	11.74	0.50	4.33	141	1093.00	52.06	403.57
1/22/95 8:00	89	2.54	14.28	0.68	3.85	345	1438.00	93.03	387.78
<b>Total Hours</b>	<b>89.00</b>	<b>Rate (GPH)</b>	<b>0.16</b>	<b>Rate (GPD)</b>	<b>3.85</b>	<b>Rate (GPH)</b>	<b>16.16</b>	<b>Rate (GPD)</b>	<b>387.78</b>



## Pumping Test Data

Site:	Travis AFB
Operators:	Place/Foor
Test Type:	Vacuum Enhancement

**Depth to GW (ft):** \_\_\_\_\_  
**Depth to Tube (ft):** \_\_\_\_\_

## Depth to Fu

[illegible]



## Fuel and Water Recovery Data

Site: Travis AFB  
 Test Type: Drawdown

Start Date: 1/23/95  
 Operators: Place/Foor

Date/Time (mm/dd/yr hr:min)	Elapsed Time (min)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gpm)	Avg. Rate (gpm)	Collected (gal)	Total (gal)	Rate (gpm)	Avg. Rate (gpm)
1/23/95 10:00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1/23/95 16:30	390	1.21	1.21	0.00	0.00	0	0.00	0.00	0.00
1/23/95 22:15	735	0.58	1.79	0.00	0.00	541	541.00	0.74	0.74
1/24/95 10:00	1440	1.45	3.24	0.00	0.00	569	1110.00	0.40	0.77
<b>Total Hours</b>	24.00	<b>Rate (GPH)</b>	0.14			<b>Rate (GPH)</b>	46.25		



Are these correct?  
Compare to  
Start Table 2  
Start  
W

**Start**  
**W**

Tube  
Depth to Fuel (ft): 9.70

[illegible]



## Fuel and Water Recovery Data

Site: Travis AFB  
 Test Type: Drawdown

Start Date: 1/24/95  
 Operators: Place/Foor

Date/Time (mm/dd/yr hr:min)	Elapsed Time (min)	LNAPL Recovery				Groundwater Recovery			
		Collected (gal)	Total (gal)	Rate (gpm)	Avg. Rate (gpm)	Collected (gal)	Total (gal)	Rate (gpm)	Avg. Rate (gpm)
1/24/95 10:25	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1/24/95 17:40	435	0.97	0.97	0.00	0.00	162	162.00	0.37	0.37
1/25/95 8:45	1340	2.41	3.38	0.00	0.00	324	486.00	0.24	0.36
1/26/95 10:30	2885	4.14	7.52	0.00	0.00	661	1147.00	0.23	0.40
<b>Total Hours</b>	48.08	<b>Rate (GPH)</b>	0.16			<b>Rate (GPH)</b>	23.85		



## Pumping Test Data

**Site:** Travis AFB  
**Operators:** Place/Foor  
**Test Type:** Drawdown

Start  
Start  
W

Depth to GW (ft):	8.16
Depth to <del>Tube</del> Fuel (ft):	8.20

Depth to ~~Fuel~~ <sup>Tube</sup> (ft): 10.70

[illegible]



**APPENDIX C**

**ANALYTICAL DATA REPORTS**





# Alpha Analytical, Inc.

255 Glendale Avenue, Suite 21

Sparks, Nevada 89431

(702) 355-1044

FAX: 702-355-0406

1-800-283-1183

Boise, Idaho

(208) 336-4145

Las Vegas, Nevada

(702) 386-6747

## ANALYTICAL REPORT

Battelle  
505 King Ave  
Columbus Ohio 43201

Job#: 9462201/Travis AFB  
Phone: (614) 424-6122  
Attn: Jeff Kittel

Sampled: 01/11/95 Received: 01/23/95 Analyzed: 01/23-24/95

Matrix: [ X ] Soil [ ] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable  
Quantitated As Gasoline

BTXE - Benzene, Toluene, Xylenes, Ethylbenzene

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191  
BTXE - Method 624/8240

### Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit
JFSA-1-MPA-1 /BMI012395-01	TPH (Purgeable)	12,000	1,000 mg/Kg
	Benzene	63,000	2,000 ug/Kg
	Toluene	220,000	2,000 ug/Kg
	Total Xylenes	370,000	2,000 ug/Kg
	Ethylbenzene	80,000	2,000 ug/Kg
JFSA-1-MPC-1 /BMI012395-02	TPH (Purgeable)	4,200	1,000 mg/Kg
	Benzene	22,000	2,000 ug/Kg
	Toluene	84,000	2,000 ug/Kg
	Total Xylenes	150,000	2,000 ug/Kg
	Ethylbenzene	33,000	2,000 ug/Kg
JFSA-1-MPC-2 /BMI012395-03	TPH (Purgeable)	1,500	1,000 mg/Kg
	Benzene	8,100	2,000 ug/Kg
	Toluene	29,000	2,000 ug/Kg
	Total Xylenes	55,000	2,000 ug/Kg
	Ethylbenzene	12,000	2,000 ug/Kg
JFSA-1-MPC-3 /BMI012395-04	TPH (Purgeable)	2,100	1,000 mg/Kg
	Benzene	9,500	2,000 ug/Kg
	Toluene	38,000	2,000 ug/Kg
	Total Xylenes	80,000	2,000 ug/Kg
	Ethylbenzene	18,000	2,000 ug/Kg

Approved by:

*Roger L. Scholl*  
Roger L. Scholl, Ph.D.  
Laboratory Director

Date:

*2/2/95*





# Alpha Analytical, Inc.

255 Glendale Avenue, Suite 21  
Sparks, Nevada 89431  
(702) 355-1044  
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1-800-283-1183

Boise, Idaho  
(208) 336-4145

Las Vegas, Nevada  
(702) 386-6747

## ANALYTICAL REPORT

Battelle  
505 King Ave  
Columbus Ohio 43201

Job#: 9462201/Travis AFB  
Phone: (614) 424-6122  
Attn: Jeff Kittel

Sampled: 01/18-20/95    Received: 01/23/95    Analyzed: 01/26/95

Matrix: [   ] Soil    [ X ] Water    [   ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable  
Quantitated As Gasoline  
BTXE - Benzene, Toluene, Xylenes, Ethylbenzene

Methodology:    TPH - Modified 8015/DHS LUFT Manual/BLS-191  
BTXE - Method 624/8240

### Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit
JFSA-1-WS-1 /BMI012395-05	TPH (Purgeable)	11	5.0 mg/L
	Benzene	910	10 ug/L
	Toluene	1,800	10 ug/L
	Total Xylenes	2,800	10 ug/L
	Ethylbenzene	510	10 ug/L
JFSA-1-WS-2 /BMI012395-06	TPH (Purgeable)	16	5.0 mg/L
	Benzene	1,100	10 ug/L
	Toluene	2,500	10 ug/L
	Total Xylenes	4,300	10 ug/L
	Ethylbenzene	780	10 ug/L
JFSA-1-WS-3 /BMI012395-07	TPH (Purgeable)	20	5.0 mg/L
	Benzene	1,000	10 ug/L
	Toluene	2,100	10 ug/L
	Total Xylenes	4,000	10 ug/L
	Ethylbenzene	710	10 ug/L

Approved by:

*Roger L. Scholl*  
Roger L. Scholl, Ph.D.  
Laboratory Director

Date:

*2/2/95*





## Alpha Analytical, Inc.

255 Highland Avenue, Suite 21  
Sparks, Nevada 89401  
702-355-1044  
FAX: 702-355-0406  
1-800-283-1183

Borise, Idaho  
(208) 336-4145

Las Vegas, Nevada  
(702) 386-6747

### ANALYTICAL REPORT

Battelle  
505 King Ave  
Columbus Ohio 43201

Job#: G466201-37D0701 (Travis AFB)  
Phone: (614) 424-6122  
Attn: Eric Drescher

Alpha Analytical Number: BMI020395-02

Client I.D. Number: JFSA-1-FP-2

Compound	Method	Concentration ug/Kg	Detection Limit ug/Kg	Date Analyzed
Benzene	8240	2,000,000	490,000	02/03/95
Toluene	8240	11,000,000	490,000	02/03/95
Total Xylenes	8240	35,000,000	490,000	02/03/95
Ethylbenzene	8240	8,000,000	490,000	02/03/95

C-range Compounds	Method	Percentage of Total	Detection Limit (Not Applicable)	Date Analyzed
C9<	GC/FID	47.25	NA	02/06/95
C9	GC/FID	21.55	NA	02/06/95
C10	GC/FID	13.88	NA	02/06/95
C11	GC/FID	6.54	NA	02/06/95
C12	GC/FID	3.80	NA	02/06/95
C13	GC/FID	3.03	NA	02/06/95
C14	GC/FID	2.15	NA	02/06/95
C15	GC/FID	0.95	NA	02/06/95
C16	GC/FID	0.37	NA	02/06/95
C17>	GC/FID	0.47	NA	02/06/95

ND - Not Detected

Approved by:

*Roger L. Scholl*

Roger L. Scholl, Ph.D.  
Laboratory Director

Date:

*2/16/95*





# Alpha Analytical, Inc.

255 Granddale Avenue, Suite 21

Sparks, Nevada 89431

(702) 355-1044

FAX: 702-355-0406

1-800-283-1183

Boise, Idaho  
(208) 336-4145

Las Vegas, Nevada  
(702) 386-6747

## ANALYTICAL REPORT

Battelle  
505 King Ave  
Columbus Ohio 43201

Job#: G466201-37D0701 (Travis AFB)  
Phone: (614) 424-6122  
Attn: Eric Drescher

Alpha Analytical Number: BMI020395-01

Client I.D. Number: JFSA-1-FP-1

Compound	Method	Concentration ug/Kg	Detection Limit ug/Kg	Date Analyzed
Benzene	8240	2,200.000	260.000	02/07/95
Toluene	8240	11,000.000	260.000	02/07/95
Total Xylenes	8240	35,000.000	260.000	02/07/95
Ethylbenzene	8240	7,900.000	260.000	02/07/95

Orange Compounds	Method	Percentage of Total	Detection Limit (Not Applicable)	Date Analyzed
C9<	GC/FID	48.67	NA	02/06/95
C9	GC/FID	20.85	NA	02/06/95
C10	GC/FID	13.24	NA	02/06/95
C11	GC/FID	6.49	NA	02/06/95
C12	GC/FID	3.90	NA	02/06/95
C13	GC/FID	3.00	NA	02/06/95
C14	GC/FID	2.17	NA	02/06/95
C15	GC/FID	0.94	NA	02/06/95
C16	GC/FID	0.37	NA	02/06/95
C17>	GC/FID	0.8	NA	02/06/95

ND - Not Detected

Approved by:

*Roger L. Scholl*  
Roger L. Scholl, Ph.D.  
Laboratory Director

Date:

*2/16/95*



**Alpha Analytical, Inc.**

Name \_\_\_\_\_  
Address \_\_\_\_\_  
City, State, Zip \_\_\_\_\_  
Phone Number \_\_\_\_\_



**Alpha Analytical, Inc.**  
255 Glendale Avenue, Suite 210  
Sparks, Nevada 89431  
Phone (702) 355-1044  
Fax (702) 355-0406

Page # 7 of       

Client Name	123456789		P.O. #	12345
Address	123456789		Phone #	123456789
City, State, Zip	123456789		Report Attention	

[illegible]

Relinquished by	Signature	Print Name
Received by		
Relinquished by		
Received by		
Relinquished by		
Received by		

**NOTE:** Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

\*Key: AQ - Aqueous      SO - Soil      WA - Waste      OT - Other





# Alpha Analytical, Inc.

2770 Canyon Avenue, Suite 2

Sparks, Nevada 89431

702-355-1044

FAX: 702-355-0406

1-800-283-1183

Boise, Idaho

(208) 336-4145

Las Vegas, Nevada

(702) 386-6747

## ANALYTICAL REPORT

Battelle  
505 King Ave  
Columbus Ohio 43201

Job#: 91138/Travis AFB  
Phone: (614) 424-6122  
Attn: Jeff Kittel

Sampled: 01/21/95      Received: 02/03/95      Analyzed: 02/03/95

Matrix: [   ] Soil      [ X ] Water      [   ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable  
Quantitated As Gasoline

BTXE - Benzene, Toluene, Xylenes, Ethylbenzene

Methodology:      TPH - Modified 8015/DHS LUFT Manual/BLS-191  
BTXE - Method 624/8240

### Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit
JFSA-1-WS-4	TPH (Purgeable)	20	5.0 mg/L
/BMI020395-03	Benzene	1,100	10 ug/L
	Toluene	2,500	10 ug/L
	Total Xylenes	4,400	10 ug/L
	Ethylbenzene	810	10 ug/L

Approved by:

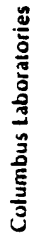
*Roger L. Scholl*

Date:

*2/16/95*

Roger L. Scholl, Ph.D.  
Laboratory Director





# CHAIN OF CUSTODY RECORD

Form No.

[illegible]





Sierra  
Environmental  
Monitoring, Inc.

February 13, 1995

TO: Alpha Analytical  
FROM: Sierra Environmental Monitoring, Inc.  
RE: Particle Size Distribution Analysis - SEM 9501-397  
BMI012395-01-JFSA-1-MPA-1

As per your request, we have performed particle size analysis on the sample submitted to this laboratory. Test results are as follows:

% Sand	38
% Silt	33
% Clay	29

The sample was passed through a #10 sieve prior to analysis as per procedure. All results are based on oven dry sample weights.

We appreciate this opportunity to provide our laboratory testing services. If you have any questions or require further testing, please feel free to contact us at your convenience.

Sincerely,  
SIERRA ENVIRONMENTAL MONITORING, INC.

Stephen Poole  
Assistant Manager/ Senior Chemist

hydro7.alp





Sierra  
Environmental  
Monitoring, Inc.

February 13, 1995

TO: Alpha Analytical  
FROM: Sierra Environmental Monitoring, Inc.  
RE: Particle Size Distribution Analysis - SEM 9501-398  
BMI012395-02-JFSA-1-MPC-1

As per your request, we have performed particle size analysis on the sample submitted to this laboratory. Test results are as follows:

% Sand	51
% Silt	24
% Clay	25

The sample was passed through a #10 sieve prior to analysis as per procedure. All results are based on oven dry sample weights.

We appreciate this opportunity to provide our laboratory testing services. If you have any questions or require further testing, please feel free to contact us at your convenience.

Sincerely,  
SIERRA ENVIRONMENTAL MONITORING, INC.

Stephen Poole  
Assistant Manager/ Senior Chemist

hydro7.alp





Sierra  
Environmental  
Monitoring, Inc.

February 13, 1995

TO: Alpha Analytical  
FROM: Sierra Environmental Monitoring, Inc.  
RE: Particle Size Distribution Analysis - SEM 9501-399  
BMI012395-03-JFSA-1-MPC-2

As per your request, we have performed particle size analysis on the sample submitted to this laboratory. Test results are as follows:

% Sand	54
% Silt	22
% Clay	24

The sample was passed through a #10 sieve prior to analysis as per procedure. All results are based on oven dry sample weights.

We appreciate this opportunity to provide our laboratory testing services. If you have any questions or require further testing, please feel free to contact us at your convenience.

Sincerely,  
SIERRA ENVIRONMENTAL MONITORING, INC.

Stephen Poole  
Assistant Manager/ Senior Chemist

hydro7.alp

William F. Pillsbury  
President

1135 Financial Blvd.  
Reno, NV 89502  
Phone (702) 857-2400  
FAX (702) 857-2404

John C. Seher  
Manager





Sierra  
Environmental  
Monitoring, Inc.

February 13, 1995

TO: Alpha Analytical  
FROM: Sierra Environmental Monitoring, Inc.  
RE: Particle Size Distribution Analysis - SEM 9501-400  
BMI012395-04-JFSA-1-MPC-1

As per your request, we have performed particle size analysis on the sample submitted to this laboratory. Test results are as follows:

% Sand	54
% Silt	23
% Clay	23

The sample was passed through a #10 sieve prior to analysis as per procedure. All results are based on oven dry sample weights.

We appreciate this opportunity to provide our laboratory testing services. If you have any questions or require further testing, please feel free to contact us at your convenience.

Sincerely,  
SIERRA ENVIRONMENTAL MONITORING, INC.

Stephen Poole  
Assistant Manager/ Senior Chemist

hydro7.alp



# Laboratory Analysis Report



**Sierra  
Environmental  
Monitoring, Inc.**

ALPHA ANALYTICAL  
255 GLENDALE AVENUE, SUITE 21  
SPARKS NV 89431

Date : 2/13/95  
Client : ALP-855  
Taken by: JEFF KITTEL  
Report : 12206  
PO# :

Page: 1

Sample	Collected		ALKALINITY	PH	MOISTURE	NITRATE-N	KJELDAHL-N	PHOSPHORUS
	Date	Time	MG/L CaCO3	S.U.	CONTENT	MG/L	MG/L	-TOTAL
					%			MG/L
BMI012395-01 - JFSA-1-MPA-1	1/11/95	:	32C 648	9.56	15.2	3.6 ug/g	3.3 mg/g	0.94ug/g
BMI012395-02 - JFSA-1-MPC-1	1/11/95	:	32C 688	9.53	14.5	2.8 ug/g	4.7 mg/g	1.48ug/g
BMI012395-03 - JFSA-1-MPC-2	1/11/95	:	208	7.75	14.5	2.0 ug/g	4.0 mg/g	5.61ug/g
BMI012395-04 - JFSA-1-MPC-3	1/11/95	:	138	7.40	12.2	2.2 ug/g	5.3 mg/g	6.17ug/g

Sample	Collected		TOTAL	IRON, TOTAL	DIGESTION-	PARTICLE SIZE	DENSITY	POROSITY
	Date	Time	NITROGEN	MG/L	TOTAL METALS	CLASSIF.	G/CM3	%
			MG/L			HYDROMETER		
BMI012395-01 - JFSA-1-MPA-1	1/11/95	:	3.3 mg/g	36 mg/g	YES	YES	1.50	43.4
BMI012395-02 - JFSA-1-MPC-1	1/11/95	:	4.7 mg/g	30 mg/g	YES	YES	1.56	41.1
BMI012395-03 - JFSA-1-MPC-2	1/11/95	:	4.0 mg/g	29 mg/g	YES	YES	1.32	50.2
BMI012395-04 - JFSA-1-MPC-3	1/11/95	:	5.3 mg/g	31 mg/g	YES	YES	1.61	39.2

Approved By:

This report is applicable only to the sample received by the laboratory. The liability of the laboratory is limited to the amount paid for this report. This report is for the exclusive use of the client to whom it is addressed and upon the condition that the client assumes all liability for the further distribution of the report or its contents.

William F. Pillsbury  
President

1135 Financial Blvd.  
Reno, NV 89502  
Phone (702) 857-2400  
FAX (702) 857-2404

John C. Seher  
Manager









Name  
Address  
City, State, Zip  
Phone Number

Client Name  
Address  
City, State, Zip

Report Attention  
Phone #

Jeff Kettel

Time Sampled  
Date Sampled  
Type\* See Key Below

Lab ID Number

Sample Description

Sampled by

Number of Containers

Remarks

Analyses Required

TPH  
BTEX  
MOS  
MOS-2  
MOS-3  
MOS-4  
MOS-5  
MOS-6  
MOS-7  
MOS-8  
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MOS-100

Relinquished by

Received by

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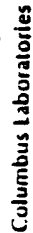
Received by

Signature	Print Name	Company	Date	Time
	Linda Cerner	Alpha Analytical	1/23/95	0900

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client at client expense.

\*Key: AQ - Aqueous SO - Soil WA - Waste OT - Other





## Form No.

2



**Alpha Analytical, Inc.**

255 Glendale Avenue, Suite 21

Sparks, Nevada 89431

(702) 355-1044

FAX: 702-355-0406

1-800-283-1183

Boise, Idaho

(208) 336-4145

2810 W. Charleston, Suite G67

Las Vegas, Nevada 89102

(702) 386-6747

**ALPHA ANALYTICAL FAX COVER SHEET**

DATE: \_\_\_\_\_

TIME: \_\_\_\_\_

FROM: PandyTO: Matt

NUMBER OF PAGES TO FOLLOW: \_\_\_\_\_

COMMENTS: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



**Alpha Analytical, Inc.**

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(702) 386-6747

**ANALYTICAL REPORT**

Battelle  
505 King Ave  
Columbus Ohio 43201

Job#: 9462201/Travis AFB  
Phone: (614) 424-6122  
Attn: Jeff Kittel

Sampled: 01/11/95      Received: 01/23/95      Analyzed: 01/23-24/95

Matrix: [ X ] Soil      [   ] Water      [   ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable  
Quantitated As Gasoline  
BTXE - Benzene, Toluene, Xylenes, Ethylbenzene

Methodology:      TPH - Modified 8015/DHS LUFT Manual/BLS-191  
BTXE - Method 624/8240

**Results:**

Client ID/ Lab ID	Parameter	Concentration	Detection Limit
JFSA-1-MPA-1 /BMI012395-01	TPH (Purgeable)	12,000	1,000 mg/Kg
	Benzene	63,000	2,000 ug/Kg
	Toluene	220,000	2,000 ug/Kg
	Total Xylenes	370,000	2,000 ug/Kg
	Ethylbenzene	80,000	2,000 ug/Kg
JFSA-1-MPC-1 /BMI012395-02	TPH (Purgeable)	4,200	1,000 mg/Kg
	Benzene	22,000	2,000 ug/Kg
	Toluene	84,000	2,000 ug/Kg
	Total Xylenes	150,000	2,000 ug/Kg
	Ethylbenzene	33,000	2,000 ug/Kg
JFSA-1-MPC-2 /BMI012395-03	TPH (Purgeable)	1,500	1,000 mg/Kg
	Benzene	8,100	2,000 ug/Kg
	Toluene	29,000	2,000 ug/Kg
	Total Xylenes	55,000	2,000 ug/Kg
	Ethylbenzene	12,000	2,000 ug/Kg
JFSA-1-MPC-3 /BMI012395-04	TPH (Purgeable)	2,100	1,000 mg/Kg
	Benzene	9,500	2,000 ug/Kg
	Toluene	38,000	2,000 ug/Kg
	Total Xylenes	80,000	2,000 ug/Kg
	Ethylbenzene	18,000	2,000 ug/Kg

Approved by:

*Roger L. Scholl*  
Roger L. Scholl, Ph.D.

Laboratory Director

Date:

*2/2/95*



**Alpha Analytical, Inc.**

255 Glendale Avenue, Suite 21  
Sparks, Nevada 89431  
(702) 355-1044  
FAX: 702-355-0406  
1-800-283-1183

Boise, Idaho  
(208) 336-4145

Las Vegas, Nevada  
(702) 386-6747

**ANALYTICAL REPORT**

Battelle  
505 King Ave  
Columbus Ohio 43201

Job#: 9462201/Travis AFB  
Phone: (614) 424-6122  
Attn: Jeff Kittel

Sampled: 01/18-20/95    Received: 01/23/95    Analyzed: 01/26/95

Matrix: [   ] Soil    [ X ] Water    [   ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable  
Quantitated as Gasoline  
BTXE - Benzene, Toluene, Xylenes, Ethylbenzene

Methodology:    TPH - Modified 8015/DHS LUFT Manual/BLS-191  
BTXE - Method 624/8240

**Results:**

Client ID/ Lab ID	Parameter	Concentration	Detection Limit
JFSA-1-WS-1 /BMI012395-05	TPH (Purgeable)	11	5.0 mg/L
	Benzene	910	10 ug/L
	Toluene	1,800	10 ug/L
	Total Xylenes	2,800	10 ug/L
	Ethylbenzene	510	10 ug/L
JFSA-1-WS-2 /BMI012395-06	TPH (Purgeable)	16	5.0 mg/L
	Benzene	1,100	10 ug/L
	Toluene	2,500	10 ug/L
	Total Xylenes	4,300	10 ug/L
	Ethylbenzene	780	10 ug/L
JFSA-1-WS-3 /BMI012395-07	TPH (Purgeable)	20	5.0 mg/L
	Benzene	1,000	10 ug/L
	Toluene	2,100	10 ug/L
	Total Xylenes	4,000	10 ug/L
	Ethylbenzene	710	10 ug/L

Approved by:

*Roger L. Scholl*  
Roger L. Scholl, Ph.D.  
Laboratory Director

Date:

*2/2/95*



**AIR TOXICS LTD.**

AN ENVIRONMENTAL ANALYTICAL LABORATORY

**WORK ORDER #: 9501182****Work Order Summary**

**CLIENT:** Mr. Eric Dreschler  
Battelle  
505 King Avenue  
Columbus, OH 43201

**BILL TO:** Same

**PHONE:** 614-424-4996  
**FAX:** 614-424-3667  
**DATE RECEIVED:** 1/30/95  
**DATE COMPLETED:** 2/3/95

**INVOICE #** 5974  
**P.O. #** 91221  
**PROJECT #** 30B0201 BIOSLURPER  
**AMOUNTS:** \$541.34

<u>FRACTION #</u>	<u>NAME</u>	<u>TEST</u>	<u>RECEIPT VAC./PRES.</u>	<u>PRICE</u>
01A	JFSA-1-OGS-1	TO-3	0.8 psi	\$120.00
02A	JFSA-1-OGS-2	TO-3	0.4 psi	\$120.00
03A	JFSA-1-OGS-3	TO-3	0.4 psi	\$120.00
04A	JFSA-1-OGS-4	TO-3	0.4 psi	\$120.00
04B	JFSA-1-OGS-4 Duplicate	TO-3	0.4 psi	NC
05A	Method Spike	TO-3	NA	NC
06A	Lab Blank	TO-3	NA	NC

Misc. Charges	1 Liter SUMMA Canister Preparation (4) @ \$10.00 each.	\$40.00
	Shipping (1/6/95)	\$21.34

CERTIFIED BY:

*J. J. Thompson*  
Laboratory Director

DATE:

*2/3/95*



**AIR TOXICS LTD.**

SAMPLE NAME: JFSA-1-OGS-1

ID#: 9501182-01A

**EPA METHOD TO-3**  
(Aromatic Volatile Organics in Air)**GC/PID**

File Name: 6013123		Date of Collection: 1/18/95		
Dil. Factor: 1600		Date of Analysis: 1/31/95		
Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	1.6	5.2	93	300
Toluene	1.6	6.1	200	760
Ethyl Benzene	1.6	7.1	64	280
Total Xylenes	1.6	7.1	260	1100

**TOTAL PETROLEUM HYDROCARBONS****GC/FID**

(Quantitated as Jet Fuel)

File Name: 6013123		Date of Collection: 1/18/95		
Dil. Factor: 1600		Date of Analysis: 1/31/95		
Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	16	100	10000	65000
C2 - C4** Hydrocarbons	16	29	Not Detected	Not Detected

\*TPH referenced to Jet Fuel (MW=156)

\*\*C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter SUMMA Canister



**AIR TOXICS LTD.**

SAMPLE NAME: JFSA-1-OGS-2

ID#: 9501182-02A

**EPA METHOD TO-3**  
(Aromatic Volatile Organics in Air)**GC/PID**

File Name: 6013124		Date of Collection: 1/18/95		
Dil Factor: 1600		Date of Analysis: 1/31/95		
Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	1.6	5.2	96	310
Toluene	1.6	6.1	190	730
Ethyl Benzene	1.6	7.1	59	260
Total Xylenes	1.6	7.1	230	1000

**TOTAL PETROLEUM HYDROCARBONS****GC/FID**

(Quantitated as Jet Fuel)

File Name: 6013124		Date of Collection: 1/18/95		
Dil Factor: 1600		Date of Analysis: 1/31/95		
Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	16	100	10000	65000
C2 - C4** Hydrocarbons	16	29	Not Detected	Not Detected

\*TPH referenced to Jet Fuel (MW=156)

\*\*C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter SUMMA Canister



**AIR TOXICS LTD.**

SAMPLE NAME: JFSA-1-OGS-3

ID#: 9501182-03A

**EPA METHOD TO-3**  
(Aromatic Volatile Organics in Air)**GC/PID**

File Name: 6013125		Date of Collection: 1/20/95		
Dil. Factor: 1600		Date of Analysis: 1/31/95		
Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	1.6	5.2	79	260
Toluene	1.6	6.1	180	690
Ethyl Benzene	1.6	7.1	56	250
Total Xylenes	1.6	7.1	230	1000

**TOTAL PETROLEUM HYDROCARBONS****GC/FID**

(Quantitated as Jet Fuel)

File Name: 6013125		Date of Collection: 1/20/95		
Dil. Factor: 1600		Date of Analysis: 1/31/95		
Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	16	100	9200	60000
C2 - C4** Hydrocarbons	16	29	Not Detected	Not Detected

\*TPH referenced to Jet Fuel (MW=156)

\*\*C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter SUMMA Canister



**AIR TOXICS LTD.**

SAMPLE NAME: JFSA-1-OGS-4

ID#: 9501182-04A

**EPA METHOD TO-3**  
(Aromatic Volatile Organics in Air)**GC/PID**

<b>File Name:</b>	<b>6013126</b>	<b>Date of Collection:</b>	<b>1/21/95</b>
<b>Dil. Factor:</b>	<b>1600</b>	<b>Date of Analysis:</b>	<b>1/31/95</b>

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	1.6	5.2	130	420
Toluene	1.6	6.1	290	1100
Ethyl Benzene	1.6	7.1	79	350
Total Xylenes	1.6	7.1	310	1400

**TOTAL PETROLEUM HYDROCARBONS****GC/FID**

(Quantitated as Jet Fuel)

<b>File Name:</b>	<b>6013126</b>	<b>Date of Collection:</b>	<b>1/21/95</b>
<b>Dil. Factor:</b>	<b>1600</b>	<b>Date of Analysis:</b>	<b>1/31/95</b>

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	16	100	14000	91000
C2 - C4** Hydrocarbons	16	29	84	150

\*TPH referenced to Jet Fuel (MW=156)

\*\*C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter SUMMA Canister



**AIR TOXICS LTD.**

SAMPLE NAME: JFSA-1-OGS-4 Duplicate

ID#: 9501182-04B

**EPA METHOD TO-3**

(Aromatic Volatile Organics in Air)

**GC/PID**

<b>File Name:</b>	<b>6013127</b>	<b>Date of Collection:</b>	<b>1/21/95</b>
<b>Dil Factor:</b>	<b>1600</b>	<b>Date of Analysis:</b>	<b>1/31/95</b>

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	1.6	5.2	120	390
Toluene	1.6	6.1	280	1100
Ethyl Benzene	1.6	7.1	76	340
Total Xylenes	1.6	7.1	300	1300

**TOTAL PETROLEUM HYDROCARBONS****GC/FID**

(Quantitated as Jet Fuel)

<b>File Name:</b>	<b>6013127</b>	<b>Date of Collection:</b>	<b>1/21/95</b>
<b>Dil Factor:</b>	<b>1600</b>	<b>Date of Analysis:</b>	<b>1/31/95</b>

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	16	100	13000	84000
C2 - C4** Hydrocarbons	16	29	82	150

\*TPH referenced to Jet Fuel (MW=156)

\*\*C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter SUMMA Canister



**AIR TOXICS LTD.**

SAMPLE NAME: Method Spike

ID#: 9501182-05A

**EPA METHOD TO-3**

(Aromatic Volatile Organics in Air)

**GC/PID**

<b>File Name:</b>	<b>6013116</b>	<b>Date of Collection:</b>	<b>NA</b>
<b>Dil. Factor:</b>	<b>1.0</b>	<b>Date of Analysis:</b>	<b>1/31/95</b>

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	% Recovery
Benzene	0.001	0.003	80
Toluene	0.001	0.004	85
Ethyl Benzene	0.001	0.004	79
Total Xylenes	0.001	0.004	82

**TOTAL PETROLEUM HYDROCARBONS****GC/FID**

(Quantitated as Jet Fuel)

<b>File Name:</b>	<b>6013117</b>	<b>Date of Collection:</b>	<b>NA</b>
<b>Dil. Factor:</b>	<b>1.0</b>	<b>Date of Analysis:</b>	<b>1/31/95</b>

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	% Recovery
TPH* (C5+ Hydrocarbons)	0.010	0.065	81
C2 - C4** Hydrocarbons	0.010	0.018	81

\*TPH referenced to Jet Fuel (MW=156)

\*\*C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: NA



**AIR TOXICS LTD.**

SAMPLE NAME: Lab Blank

ID#: 9501182-06A

**EPA METHOD TO-3**  
(Aromatic Volatile Organics in Air)**GC/PID**

<b>File Name:</b>	<b>6013120</b>	<b>Date of Collection:</b>	<b>NA</b>
<b>Dil. Factor:</b>	<b>1.0</b>	<b>Date of Analysis:</b>	<b>1/31/95</b>

<b>Compound</b>	<b>Det. Limit (ppmv)</b>	<b>Det. Limit (uG/L)</b>	<b>Amount (ppmv)</b>	<b>Amount (uG/L)</b>
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

**TOTAL PETROLEUM HYDROCARBONS****GC/FID**

(Quantitated as Jet Fuel)

<b>File Name:</b>	<b>6013120</b>	<b>Date of Collection:</b>	<b>NA</b>
<b>Dil. Factor:</b>	<b>1.0</b>	<b>Date of Analysis:</b>	<b>1/31/95</b>

<b>Compound</b>	<b>Det. Limit (ppmv)</b>	<b>Det. Limit (uG/L)</b>	<b>Amount (ppmv)</b>	<b>Amount (uG/L)</b>
TPH* (C5+ Hydrocarbons)	0.010	0.065	Not Detected	Not Detected
C2 - C4** Hydrocarbons	0.010	0.018	Not Detected	Not Detected

\*TPH referenced to Jet Fuel (MW=156)

\*\*C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: NA





**AN ENVIRONMENTAL ANALYTICAL LABORATORY**

# CHAIN-OF-CUSTODY RECORD

Page 1 of 1

Contact Person <u>Jess K. NCC</u> Company <u>BATELL</u> Address <u>505 K. Ave</u> City <u>Columbus</u> State <u>OH</u> Zip <u>43201</u> Phone <u>(614) 424-6122</u> FAX <u>(614) 424-3667</u>		Project Info: P.O. # _____ Project # <u>TRANS AFB</u> Project Name <u>BIOBULPCL</u>		Turn Around Time: <input checked="" type="checkbox"/> Normal <input type="checkbox"/> Rush _____ Specify _____	
Lab I.D. <u>Q1A</u> <u>Q2A</u> <u>Q3A</u> <u>Q4A</u>	Field Sample I.D. <u>IFSA-1-045-1</u> <u>IFSA-1-045-2</u> <u>IFSA-1-045-3</u> <u>IFSA-1-045-4</u>	Date & Time <u>1/18/95 0800</u> <u>1/18/95 0805</u> <u>1/21/95 1030</u> <u>1/21/95 0800</u>	Analyses Requested <u>BTEX, TPH</u> <u>BTEX, TPH</u> <u>BTEX, TPH</u> <u>BTEX, TPH</u>	Canister Pressure / Vacuum Initial Final Receipt <u>30 0 0.7</u> <u>30 0 0.1</u> <u>30 0 0.1</u> <u>30 0 0.1</u>	
Collected By: <u>Phil M. Place</u> Signature _____		Notes: _____			
Relinquished By: (Signature) <u>Phil M. Place</u> Date/Time <u>1/23/95</u>		Received By: (Signature) _____ Date/Time _____			
Relinquished By: (Signature) _____ Date/Time _____		Received By: (Signature) _____ Date/Time _____			
Relinquished By: (Signature) _____ Date/Time _____		Received By: (Signature) _____ Date/Time <u>1/30/95 9:20</u>			
Shipper Name <u>FedEx</u> Air Bill # <u>122-9248 004</u>		Date/Time <u>1/30/95 9:20</u>	Temp. (°C) <u>Ambient</u>	Condition <u>Good</u>	Custody Seals Intact? <u>Yes</u> No <u>None</u>
Lab Use Only		Work Order # _____			



**APPENDIX D**

**SOIL GAS PERMEABILITY TEST RESULTS**



Travis Air Force Base MPA			
Vaccum in Inches of Water			
Time	MPA-3	MPA-5.5	MPA-8
0	0.00	0.00	0.00
1	0.00	0.80	0.00
2	0.00	0.10	0.00
5	0.00	0.12	0.01
7	0.01	0.10	0.01
8	0.01	0.10	0.01
9	0.00	0.14	0.01
10	0.02	0.15	0.15
11	0.00	0.17	0.15
12	0.00	0.18	0.16
13	0.00	0.19	0.17
14	0.00	0.21	0.18
15	0.00	0.22	0.18
16	0.00	0.23	0.19
17	0.00	0.25	0.22
20	0.00	0.25	0.24
22	0.00	0.26	0.30
24	0.00	0.29	0.31
26	0.00	0.32	0.31
28	0.00	0.34	0.32
30	0.00	0.34	0.33
35	0.00	0.35	0.34
40	0.00	0.45	0.45
50	0.00	0.50	0.49
55	0.00	0.54	0.50
60	0.00	0.55	0.55
75	nd	0.65	0.55
90	nd	0.70	0.65
105	nd	0.70	0.65
120	nd	0.70	0.65
240	0.55	0.95	0.95
870	0.55	0.55	0.60



	Travis Air Force Base MPC		
	Vacuum in Inches of Water		
Time	MPC-2.5	MPC-5.5	MPC-8
0	0.00	0.00	0.00
1	0.00	0.00	0.00
2	0.00	0.10	0.00
3	0.01	0.05	0.00
6	0.01	0.08	0.00
9	0.03	0.09	0.00
11	0.03	0.10	0.00
19	0.04	0.17	0.02
31	0.04	0.18	0.01
42	0.04	0.25	0.01
62	0.13	0.35	0.12
93	0.15	0.40	0.25
105	0.15	0.40	0.30
120	0.15	0.40	0.30
240	0.16	0.50	0.40
870	0.25	0.80	0.85



## Soil Gas Permeability

Site Name: Travis AFB

Date: 12/27/94

Item	Symbol	Value	Unit
Volumetric Flow Rate from the Vent Well	Q	47.45	cm <sup>3</sup> /s
Viscosity of Air ( $1.8 \times 10^{-4}$ g/cm-s at 64.4 °F (18° C)	u	1.80E-04	g/cm-s
Ambient pressure (at sea level $1.013 \times 10^6$ g/cm-s <sup>2</sup> )	P <sub>atm</sub>	9.46E+05	g/cm-s <sup>2</sup>
Absolute Pressure at the Venting Well	P <sub>w</sub>	9.64E+05	g/cm-s <sup>2</sup>
Radius of Venting Well	R <sub>w</sub>	15.24	cm
Depth of Screen	H	222.6	cm
Radius of Influence-Previously determined	R <sub>i</sub>	1685.01	cm
Soil Gas Permeability (for Vacuum Well)	k	0.16	darcy
Soil Gas Permeability (for Air Injection Well)	k	0.16	darcy

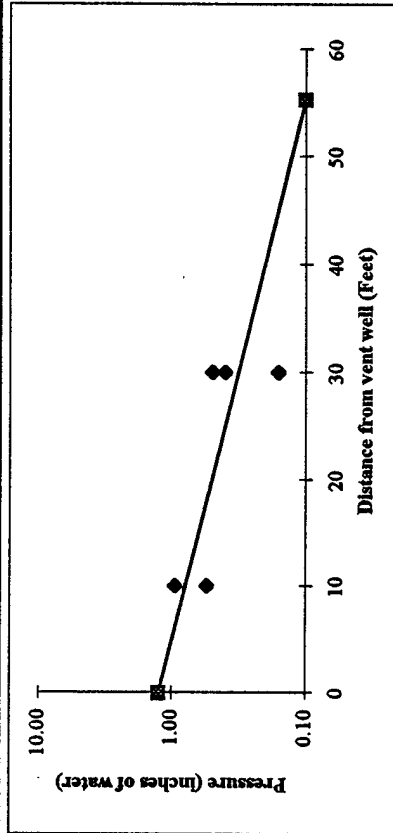


# Radius of Influence

Site Name Travis AFB

Date: 12/27/94

Time (min.)	Air Flow (cfm)	Vacuum (inches of water)													
		green	blue	red	green	blue	red	blue	black	clear	orange	yellow	blue	green	red
0.00		0.00	0.00	0.00	0.00	0.00	0.00								
9.00		0.05	0.14	0.01	0.03	0.09	0.00								
31.00		0.10	0.34	0.33	0.04	0.18	0.01								
60.00		0.15	0.55	0.55	0.13	0.35	0.22								
105.00		0.25	0.70	0.70	0.15	0.40	0.30								
120.00		0.30	0.70	0.65	0.15	0.40	0.30								
240.00		0.55	0.95	0.95	0.16	0.50	0.40								
Distance (ft)		10	10	10	30	30	30								



R<sub>i</sub>: 55.28 ft



**APPENDIX E**  
**IN SITU RESPIRATION TEST RESULTS**



# Utilization Rates (1)

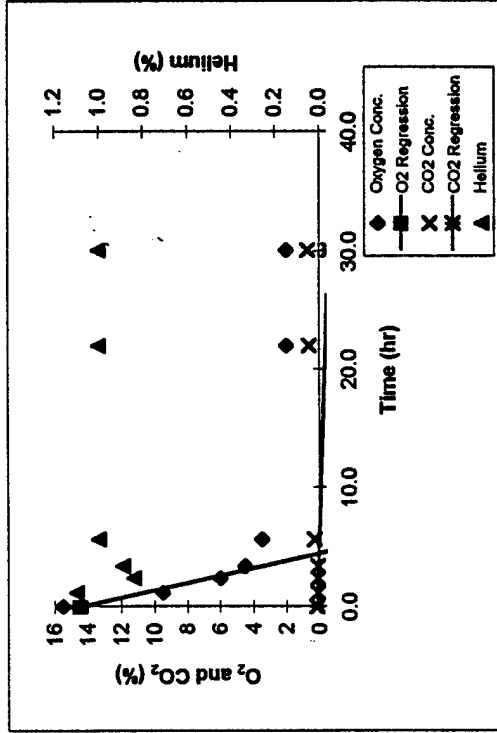
Date: 1/23/95

Site Name: Travis AFB

Monitoring Point: MPA

Depth of M.P. (ft): 5.5

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
1/23/95 11:05	0.0	15.50	0.20	1.10
1/23/95 12:15	1.2	9.50	0.10	1.10
1/23/95 13:30	2.4	6.00	0.10	0.84
1/23/95 14:30	3.4	4.50	0.10	0.89
1/23/95 16:45	5.7	3.50	0.30	1.00
1/24/95 9:05	22.0	2.00	0.60	1.00
1/24/95 17:10	30.1	2.00	0.70	1.00



## O<sub>2</sub> Utilization Rate

Ko	0.053 %/min
	3.195 %/hr
	76.679 %/day

Regression Lines	O <sub>2</sub>	CO <sub>2</sub>
Slope	-3.1950	-0.0264
Intercept	14.4662	0.1712
Determination Coef.	0.9434	0.6164
No. of Data Points.	4	4



## Utilization Rates (2)

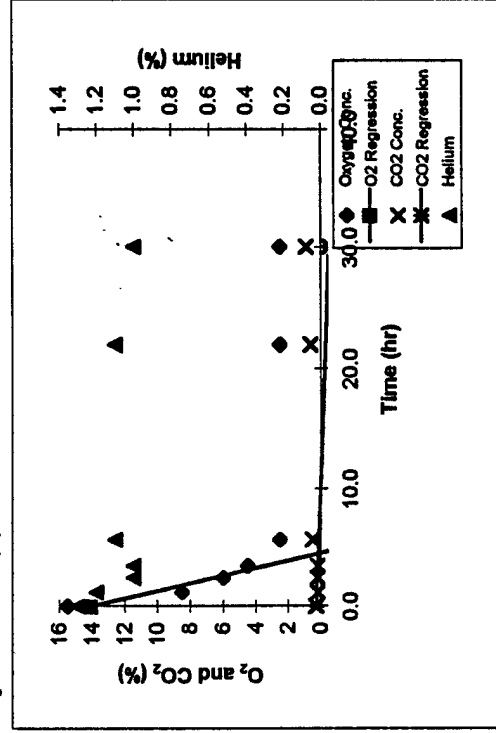
Date: 1/23/95

Site Name: Travis AFB

Monitoring Point: MPB

Depth of M.P. (ft): 8

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
1/23/95 11:05	0.0	15.50	0.30	1.30
1/23/95 12:15	1.2	8.50	0.20	1.20
1/23/95 13:30	2.4	6.00	0.20	1.00
1/23/95 14:30	3.4	4.50	0.20	1.00
1/23/95 16:45	5.7	2.50	0.50	1.10
1/24/95 9:05	22.0	2.50	0.60	1.10
1/24/95 17:10	30.1	2.50	0.90	1.00



Regression Lines	O <sub>2</sub>	CO <sub>2</sub>
Slope	-3.1069	-0.0264
Intercept	14.0621	0.2712
Determination Coef.	0.8983	0.6164
No. of Data Points.	4	4

O<sub>2</sub> Utilization Rate

K<sub>0</sub> 0.052 %/min  
3.107 %/hr  
74.566 %/day



# Utilization Rates (3)

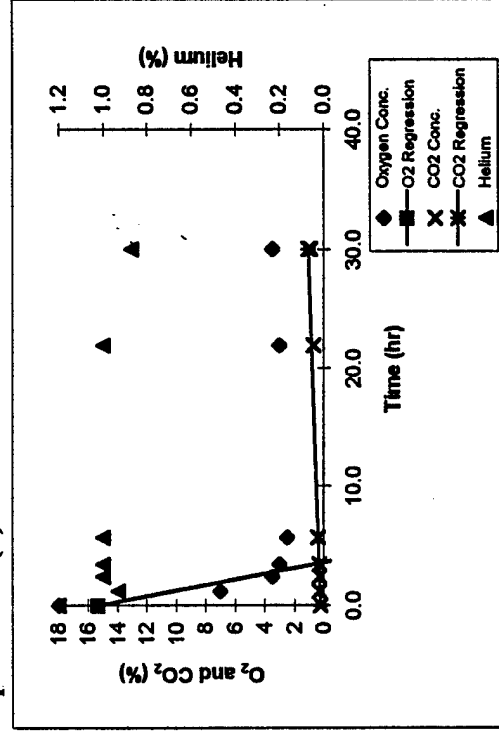
Date: 1/23/95

Site Name: Travis AFB

Monitoring Point: MPC

Depth of M.P. (ft): 5.5

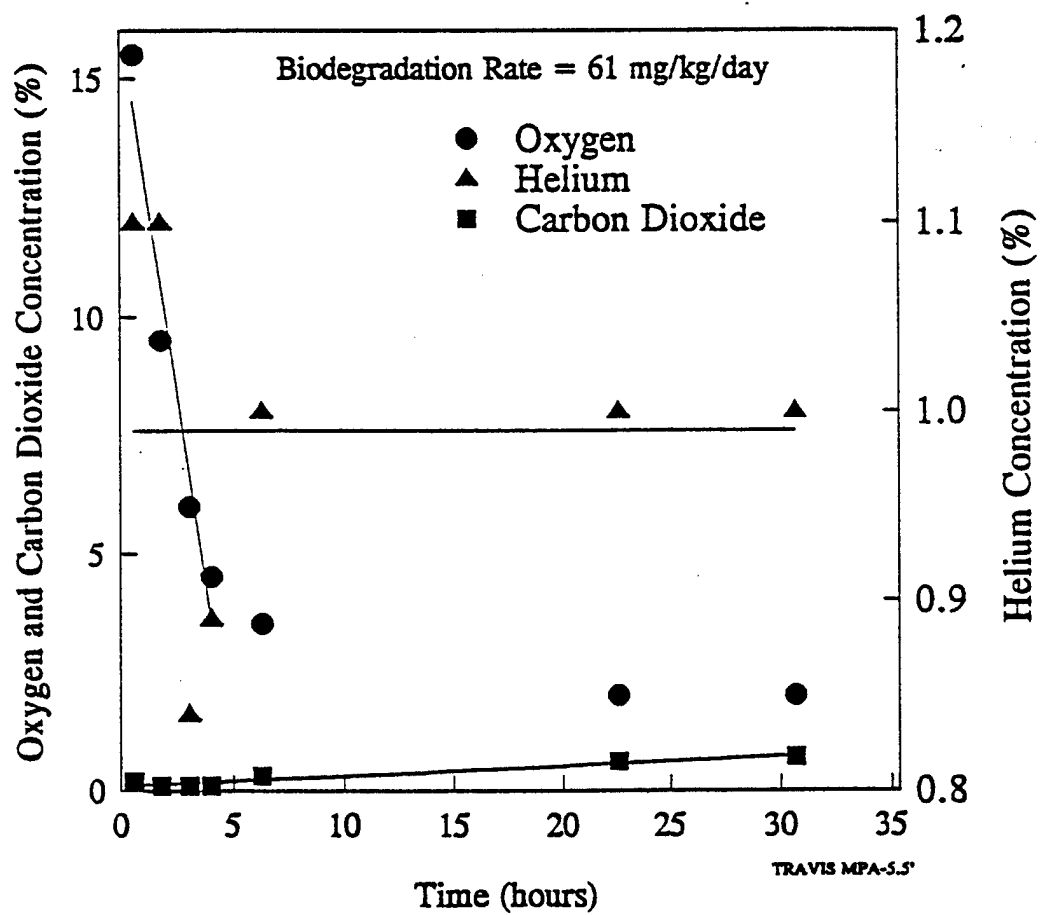
Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
1/23/95 11:05	0.0	18.00	0.20	1.20
1/23/95 12:15	1.2	7.00	0.30	0.93
1/23/95 13:30	2.4	3.50	0.30	1.00
1/23/95 14:30	3.4	3.00	0.30	1.00
1/23/95 16:45	5.7	2.50	0.40	1.00
1/24/95 9:05	22.0	3.00	0.70	1.00
1/24/95 17:10	30.1	3.50	0.90	0.87



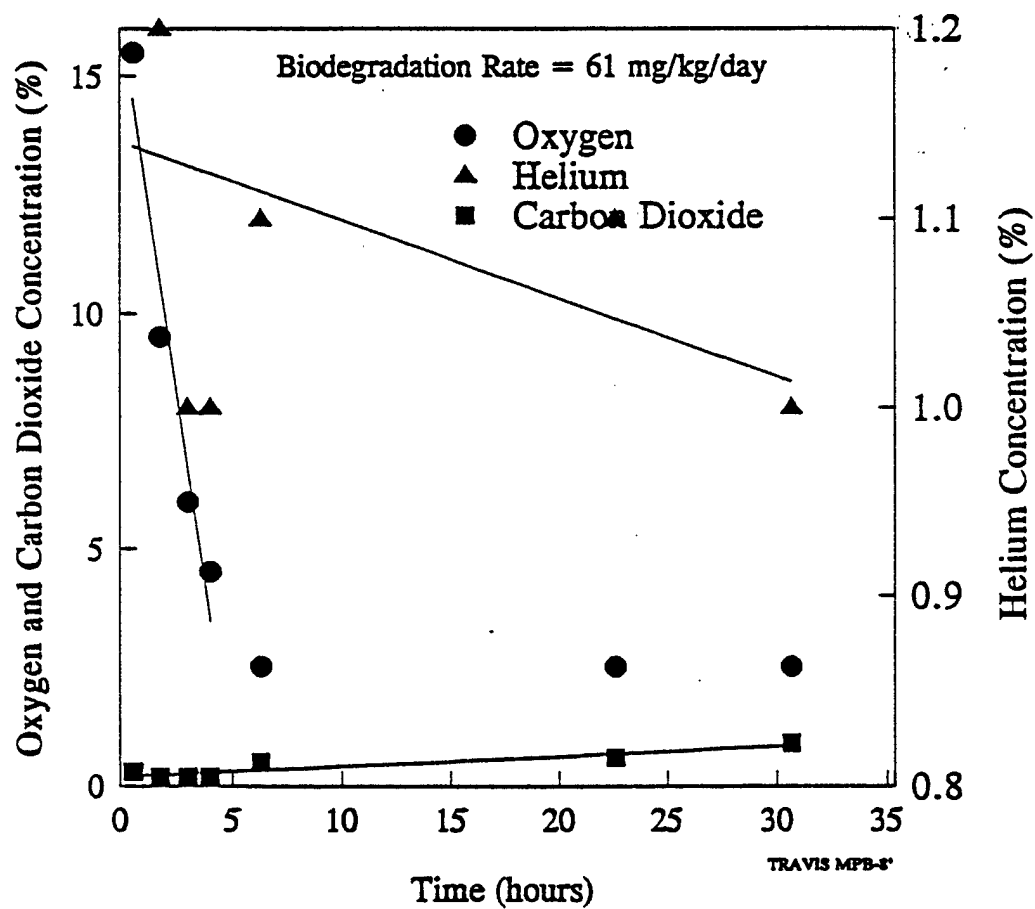
O <sub>2</sub> Utilization Rate	
K <sub>0</sub>	0.071 %/min
	4.264 %/hr
	102.340 %/day

Regression Lines	O <sub>2</sub>	CO <sub>2</sub>
Slope	-4.2642	0.0264
Intercept	15.3373	0.2288
Determination Coef.	0.8240	0.6164
No. of Data Points.	4	4

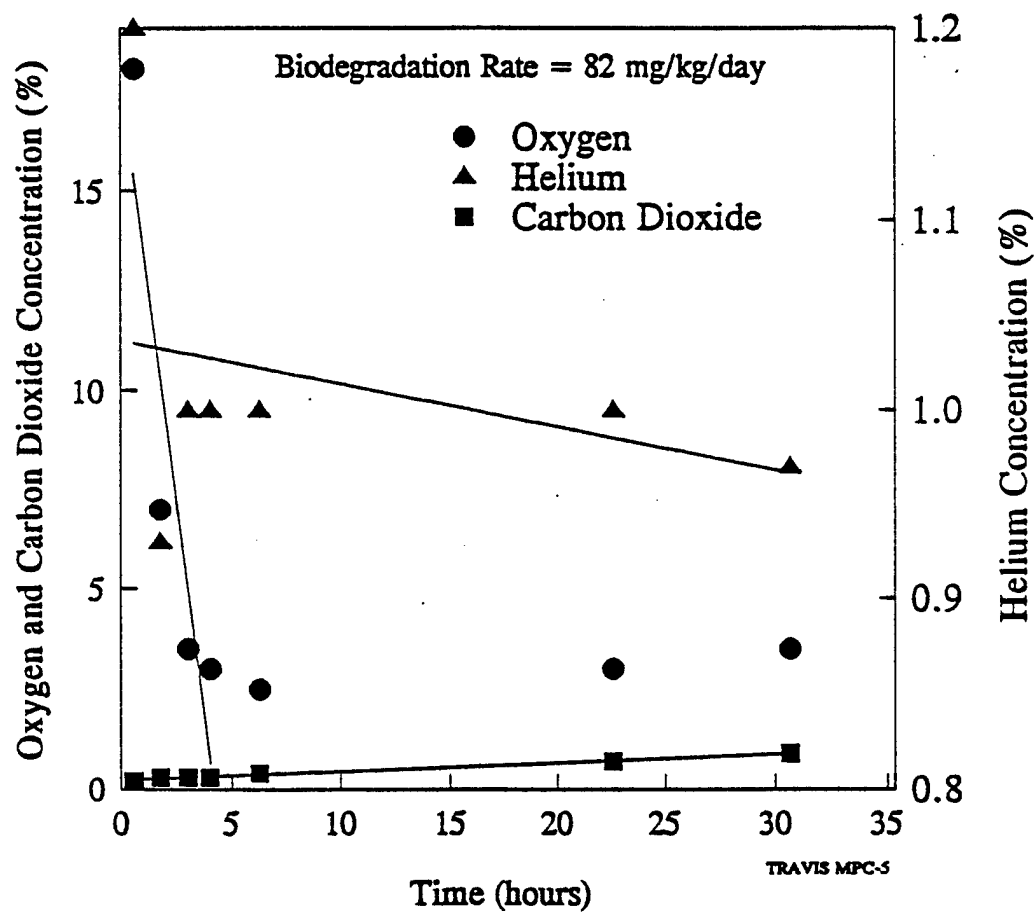








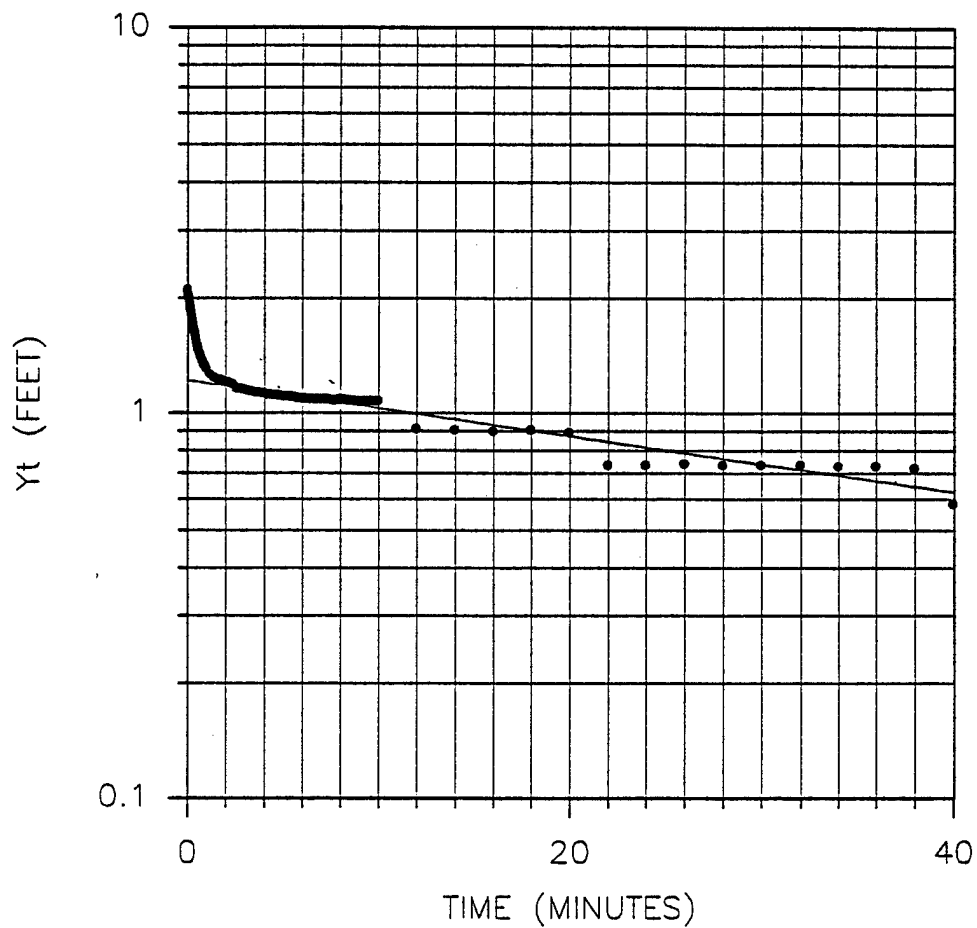






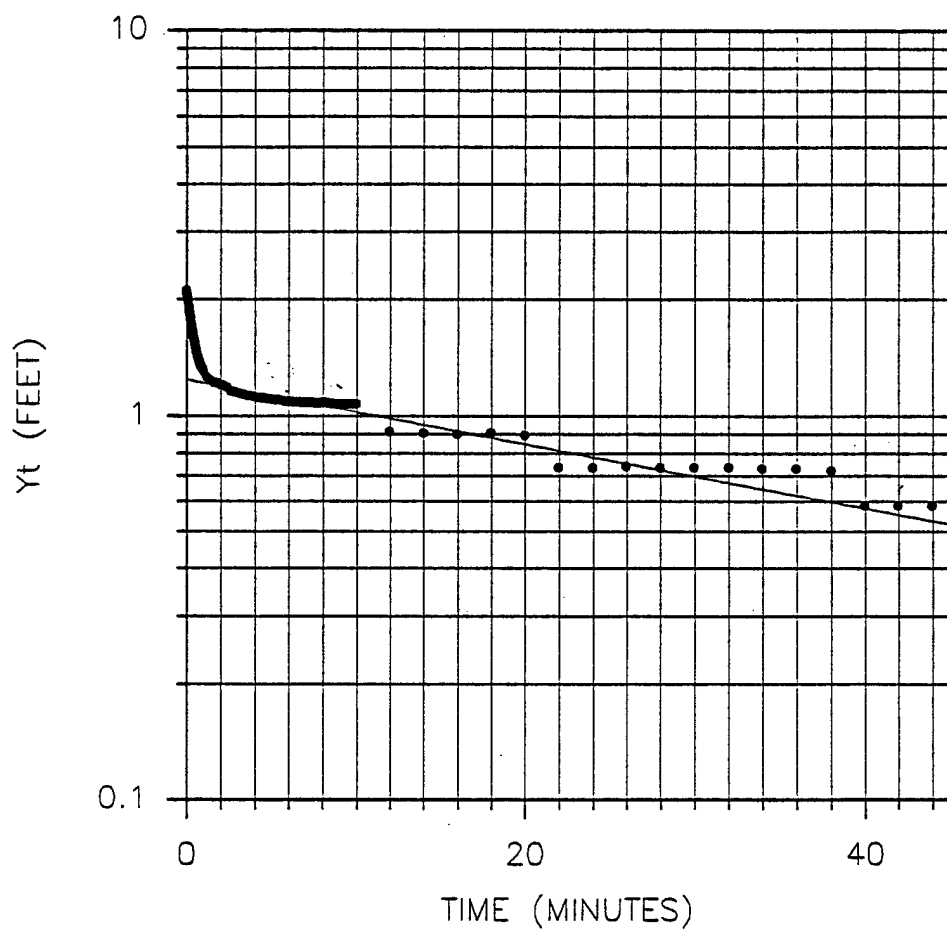
**APPENDIX F**  
**SLUG TESTING RESULTS**





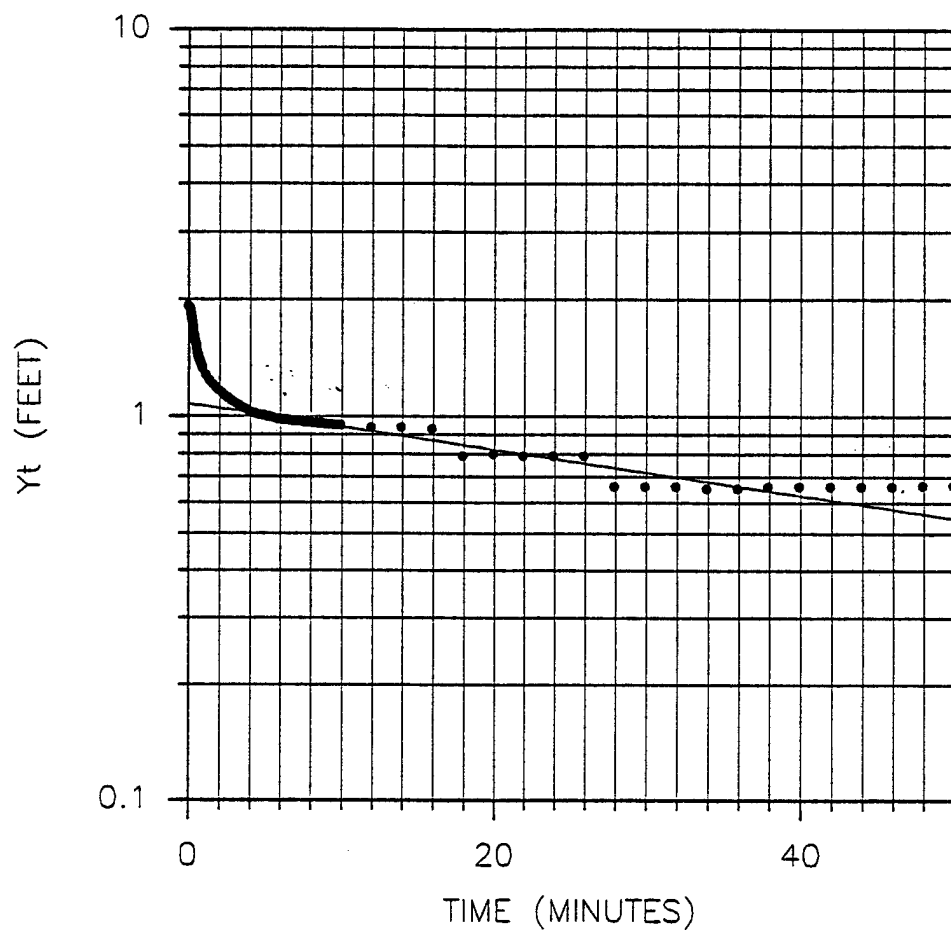
Bouwer and Rice Slug Test Analysis					
Well 5303 - Replicate #1					
D =	37	ft			
L =	15	ft			
H =	12.39	ft			
rw =	1.25	ft			
rc =	0.5	ft			
L/rw =	12.00			ln Re/rw =	1.05
A =	2			Re =	3.56
B =	1.25				
t =	18	min		K =	0.20 ft/day
Yt =	0.9	ft			
Yo =	1.2	ft			





Bouwer and Rice Slug Test Analysis					
Well 5303 - Replicate #2					
D =	37	ft			
L =	15	ft			
H =	12.39	ft			
rw =	1.25	ft			
rc =	0.5	ft			
L/rw =	12.00			ln Re/rw =	1.05
A =	2			Re =	3.56
B =	1.25				
t =	30	min		K =	0.26 ft/day
Yt =	0.7	ft			
Yo =	1.3	ft			





Bouwer and Rice Slug Test Analysis					
Well 5303 - Replicate <del>2</del> 3					
D =	37	ft			
L =	15	ft			
H =	12.39	ft			
rw =	1.25	ft			
rc =	0.5	ft			
L/rw =	12.00			ln Re/rw =	1.05
A =	2			Re =	3.56
B =	1.25				
t =	22	min		K =	0.18 ft/day
Yt =	0.8	ft			
Yo =	1.1	ft			